Table of Contents

Home Page

About the University

New Jersey Institute of Technology

Welcome to New Jersey Institute of Technology. As the state’s public polytechnic university, we continue to invest in the renewal of our existing facilities in addition to adding new spaces, with the goal of providing an exceptional teaching, learning and living environment.

Continuing a fourfold mission of instruction, research, economic development and public service, NJIT is among the leading comprehensive polytechnic universities in the nation. With well over 11,000 students, NJIT is the largest technological university in the New York metropolitan region.

The university has state-of-the-art facilities with more than 2 million square feet located on a 48-acre campus in Newark, and a solar observatory in Big Bear Lake, California. With robust distance education programs, NJIT's degree and non-degree programs are available throughout the world.

Learning at NJIT

NJIT, a top-ranked public research university, offers undergraduate and graduate students over 125 degree programs ranging from the STEM disciplines to architecture and design, as well as management and humanities.

Our interdisciplinary approach to learning offers students the ability to study in fields beyond their major. We continue to invest in our faculty and facilities so that our students learn in state-of-the-art classrooms and have access to the latest technology in our labs.

NJIT’s research is founded on collaboration with students, faculty, staff, external researchers, and partners. We are committed to providing interdisciplinary research and scholarship with the utmost professional integrity.

Our six colleges enroll more than 11,400 students, preparing them for the workplace as well as continuing on to advanced degrees.

Our extensive Continuing Professional Education programs and online courses offer important training for professionals already on the job, and our competitive industry internships help land you one of your own.

NJIT, Rutgers-Newark and Rutgers University Biomedical and Health Sciences (RBHS), New Jersey's university of the health sciences, offer 10 joint master's or doctoral degree programs, placing them as leaders in development of programs to prepare individuals for a world increasingly multidisciplinary and technological in nature.

Each year, thousands of students from NJIT, Rutgers-Newark and Rutgers University Biomedical and Health Sciences take courses at the institutions.

Our Campus Community

Our campus has doubled in size in the past decade to include new residence halls, a 190,000-square-foot Campus Center, a $102 million Wellness and Events Center and the $19 million state-of-the-art Life Sciences and Engineering Center.

NJIT is located in Newark, New Jersey's largest city. Newark is also New Jersey's cultural and economic capital, boasting performance spaces, professional sports, great food, and five other nearby colleges. We're also 20 minutes by train to New York City.

We also have remarkable students from all over the world, and are ranked #1 nationally for student upward economic mobility (*The New York Times*). NJIT gives you more than a world-class education. It gives you a community. The friends and contacts you'll make at NJIT, whether in one of over 130 student clubs and organizations (not including Greeks), or in dozens of community service projects, will enhance your life and impact your future.

Academic Calendar

Fall 2019 Academic Calendar

Month	Day	Day of Week	Description
September	2	Monday	Labor Day
September	3	Tuesday	First Day of Classes
September	7	Saturday	Saturday Classes Begin
September	9	Monday	Monday Classes Meet
September	13	Friday	Last Day to Add/Drop a Class
September	13	Friday	Last Day for 100% Refund, Full or Partial Withdrawal
September	14	Saturday	W Grades Posted for Course Withdrawals
September	16	Monday	Last Day for 90% Refund, Full or Partial Withdrawal - No Refund for Partial Withdrawal after this date
September	30	Monday	Last Day for 50% Refund, Full Withdrawal
October	21	Monday	Last Day for 25% Refund, Full Withdrawal
November	11	Monday	Last Day to Withdraw
November	26	Tuesday	Thursday Classes Meet
November	27	Wednesday	Friday Classes Meet
November	28	Thursday	Thanksgiving Recess Begins
December	1	Sunday	Thanksgiving Recess Ends
December	11	Wednesday	Last Day of Classes
December	12	Thursday	Reading Day except for Saturday classes. Saturday Classes Meet
December	13	Friday	Reading Day
December	14	Saturday	Final Exams Begin
December	20	Friday	Final Exams End
December	22	Sunday	Final Grades Due

Spring 2020 Academic Calendar

Month	Day	Day of Week	Description
January	20	Monday	Martin Luther King, Jr. Day
January	21	Tuesday	First Day of Classes
January	25	Saturday	Saturday Classes Begin
January	31	Friday	Last Day to Add/Drop a Class
January	31	Friday	Last Day for 100% Refund, Full or Partial Withdrawal
February	1	Saturday	W Grades Posted for Course Withdrawals
February	3	Monday	Last Day for 90% Refund, Full or Partial Withdrawal - No Refund for Partial Withdrawal after this date
February	17	Monday	Last Day for 50% Refund, Full Withdrawal
March	9	Monday	Last Day for 25% Refund, Full Withdrawal
March	15	Sunday	Spring Recess Begins - No Classes Scheduled - University Open
March	22	Sunday	Spring Recess Ends

April	10	Friday	Good Friday - No Classes Scheduled - University Closed
April	24	Friday	Last Day to Withdraw (extended from April 6th withdrawal)
May	5	Tuesday	Friday Classes Meet
May	5	Tuesday	Last Day of Classes
May	6	Wednesday	Reading Day 1
May	7	Thursday	Reading Day 2
May	8	Friday	Final Exams Begin
May	14	Thursday	Final Exams End
May	16	Saturday	Final Grades Due
May	31	Sunday	Graduation date (academic transcript/diploma)
June	12	Friday	Commencement-Virtual Ceremony

Accreditation

New Jersey Institute of Technology is accredited by the Middle States Commission on Higher Education, 3624 Market Street, Philadelphia, PA 19104. (267-284-5000) The Middle States Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

Most of NJIT's eligible professional programs, both graduate and undergraduate, are accredited by the respective accrediting agency for their field. Addresses and telephone numbers for all of these accrediting agencies are listed below.

Details about the accreditation of specific programs are included in the descriptions of those degrees.

ABET
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(EAC of ABET) Engineering Accreditation Commission of ABET
(TAC of ABET) Technology Accreditation Commission of ABET
111 Market Place, Suite 1050
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AACSB International
777 South Harbour Island Boulevard
Suite 750
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Tel. (813) 769-6500

Middle States Commission on Higher Education
3624 Market Street
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Tel. (215) 662-5606

National Architectural Accrediting Board, Inc. (NAAB)
1735 New York Avenue, NW
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Directory

Faculty at NJIT

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The NJIT Board of Trustees (http://catalog.njit.edu/archive/2019-2020/about-university/directory/board-of-trustees/) is the legal governing body of the university appointed by the governor and confirmed by the state senate.

Board of Overseers

The NJIT Board of Overseers (http://catalog.njit.edu/archive/2019-2020/about-university/directory/board-of-overseers/) serves as the governing body for the Foundation at NJIT and provides a key advisory link with a wide range of organizations in the business community.

Boards of Visitors

NJIT Advisory Boards (http://catalog.njit.edu/archive/2019-2020/about-university/directory/advisory-boards/) serve in an advisory capacity to departments and programs, offering guidance on issues ranging from curricular matters to recruitment efforts to marketing activities.

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Ph.D., University of Southern California, 1982
M.S., University of Southern California, 1978
B.S., University of Wisconsin, 1969

Turoff, Murray
Distinguished Professor Emeritus of Information System (1973)
Ph.D., Brandeis University, 1965

B.A., University of California, 1958

Van Buskirk, William C.
Distinguished Professor Emeritus of Biomedical Engineering (1998)
Ph.D., Stanford University, 1970
M.S., Stanford University, 1966
B.S., United States Military Academy, 1964

Venanzi, Carol A.
Distinguished Professor Emeritus of Chemistry and Environmental Science (1982)
Ph.D. Chemistry, University of California, 1978
M.S. Chemistry, Johns Hopkins University, 1970
B.A. Chemistry, Catholic University of America, 1969

Voronka, Roman W.
Professor Emeritus of Mathematical Sciences (1962)
Ph.D., New York University, 1974
M.S., New York University, 1967
M.S., Newark College of Engineering, 1964
B.S., Newark College of Engineering, 1962

Wall, Donald R.
Associate Professor Emeritus of Architecture and Design (1974)
D. Arch., Catholic University of America, 1970
M. Arch., Cornell University, 1959
B. Arch., University of Manitoba, 1958

Weisman, Leslie K.
Professor Emeritus of Architecture and Design (1975)
M.A., University of Detroit, 1973
B.F.A., Wayne State University, 1967

West, Troy
Associate Professor Emeritus of Architecture and Design (1974)
M. Arch., Carnegie Institute of Technology, 1965
B. Arch., Carnegie Institute of Technology, 1958

Wilson, Charles E.
Professor Emeritus of Mechanical and Industrial Engineering (1956)
Ph.D., City College of New York, 1951

Wolf, Carl
Professor Emeritus of Mechanical and Industrial Engineering (1961)
Ph.D.
M.S., New York University, 1971
B.B.A., Columbia University in the City of New York, 1954

Research Centers and Labs

NJIT's strategic research plan, as a part of *2020 Vision*, sets the overall goal of achieving prominence in research in key areas of high societal impact. The mission of the Office of Research is to promote the highest quality of creativity, research and innovation. To this end, our research enterprise focuses on basic, applied and translational research through four research clusters:

- Life Sciences and Engineering (https://centers.njit.edu/research-areas/life-sciences-and-engineering/)
- Sustainable Systems (https://centers.njit.edu/research-areas/sustainable-systems/)
- Data Science and Information Technology (https://centers.njit.edu/research-areas/data-science-and-information-technology/)
- Transdisciplinary Areas (https://centers.njit.edu/research-areas/transdisciplinary-areas/)

These clusters are comprised of multi-disciplinary centers of excellence that encourage partnerships among various disciplines, as well as with other educational institutions, private enterprises, and government agencies.

NJIT has more than 60 research institutes, centers and specialized laboratories that reflect the strategic growth in the university's research enterprise. Over the past three years alone, more than 25 new labs have been created; by 2020, we expect no fewer than 100.

Graduate Catalog

Graduate programs (https://www.njit.edu/graduatestudies/degree-programs/) are available to full-time students, or working professionals who are interested in part-time study. Many programs are also offered online (https://www.njit.edu/online/).

More than 3,000 students from across the country and around the world are engaged in graduate study each year at NJIT. NJIT currently offers about 50 master's degree programs, 19 doctoral degree programs, and dozens of graduate certificate (https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/) programs in a wide range of technological specialties through the following colleges and schools:

- Newark College of Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/#masterstext)
- College of Architecture and Design (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/#masterstext)
- College of Science and Liberal Arts (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/#masterstext)
- Martin Tuchman School of Management (http://catalog.njit.edu/archive/2019-2020/graduate/management/#masterstext)
- Ying Wu College of Computing (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/#masterstext)

NJIT also offers the following **program options**:

- Accelerated programs where some courses double count toward two degrees
  - BS-MS & BS-PhD program options (https://www.njit.edu/graduatestudies/degree-programs/bs-ms/)
  - MS-MS & MS-MBA program options (https://www.njit.edu/graduatestudies/degree-programs/ms-ms/)
- Collaborative doctorate program (http://catalog.njit.edu/archive/2019-2020/graduate/graduate-programs/) (for working professionals)

Professional options (https://www.njit.edu/graduatestudies/degree-programs/) are also available in some master's degree programs. Some of these options are affiliated with the PSM (Professional Science Master's) National Office.

Academic Policies and Procedures

The academic calendar lists the dates classes begin and end, dates on which the university is closed for holidays, deadline dates for registration and withdrawal and other dates of interest to the academic community. It may also be accessed at https://www.njit.edu/registrar/calendars/.

Registration for Courses at NJIT

Registration is required each semester (after receiving advice from the academic advisor in the student's academic program). The Registrar's office is located in the Student Mall, on the ground floor of the parking deck. NJIT has an advance self-registration system that obligates all students currently enrolled in graduate degree programs to register in advance for their courses.

All admitted students register online via the Registrar's website at www.njit.edu/registrar/ (http://www.njit.edu/registrar/).

Currently Enrolled Students

Currently enrolled students are informed of registration procedures for the fall and spring semesters by the Office of the Registrar during April and October, respectively, and must then register during the advance registration period. Instructions for the summer session are provided separately and mailed to students. Priority registration is provided to Veteran and service member students. Please contact the Office of Military/Veteran Students to confirm eligibility. Priority registration is provided to Veteran and service member students. Please contact the Office of Military/Veteran Students to confirm eligibility.

New and Readmitted Students

The Office of University Admissions informs prospective and readmitted students of registration procedures.

International Students

New international students are only permitted to register after attending the required international student orientation program. They must then register in person. International students who register appropriately for full-time study will be reported in the Student and Exchange Visitor Information System (SEVIS) administered by the U.S. Immigration and Customs Enforcement Agency.

Non-Matriculated Students

Non-matriculated students should contact the Office of University Admissions for details of admission and registration procedures at least one month before the date of intended enrollment. Online students should contact the Office of Graduate Studies.

Approval of Initial Registration

Students are required to arrange a conference with their graduate advisor, as soon as possible after notification of admission, to formulate a course of study that meets the requirements of the particular degree program, and reflects the interests and aspirations of the individual student. New students are required to obtain advisor approval for initial course registration. Graduate advisors are normally available for international students during the international student orientation program.

Auditing a Course

Students who wish to audit a course must state their intention to do so at the time of registration. Change in auditing status is not permitted once a semester has begun. Students who audit are required to pay full tuition and fees for the course. Financial awards are not applicable to audited courses. Audited courses are not counted in determining full-time status. Students on probation are not permitted to audit. Students who wish to attend a course must have an authorized reason for attendance and a registration in that course (regular or audit) and cannot merely "sit in" at their own discretion.

Policy on Midterm and Final Exams

NJIT policy requires that all midterm and final exams must be proctored, regardless of delivery mode, in order to increase academic integrity. Note that this does not apply to essay or authentic based assessments. Effective beginning Fall semester 2019, students registered for a fully online course section (e.g., online or Hyflex mode) must be given the option to take their exam in a completely online format, with appropriate proctoring.

Undergraduate Registration in Graduate Courses

Undergraduate students who wish to take 500 or 600-level courses must obtain the written approval of the graduate advisor for the program that offers the course and, their undergraduate advisor, and submit an **Approval for Undergraduates Taking Graduate Courses** form. Undergraduates are not permitted to take 700-level courses. Grades will follow the graduate grading system.

The undergraduate and graduate advisors will review the student's academic record prior to approval. Approval can be granted only to students who have completed the appropriate prerequisites for the course and are in satisfactory academic standing. The approval will be noted on the Approval for Undergraduates Taking Graduate Courses form that requires appropriate signatures and reports the student's cumulative undergraduate GPA. Students shall have a cumulative undergraduate GPA of 2.5 or higher to be approved for registration in 500-level courses (500G for Architecture), and 2.8 or higher for registration in 600-level courses.

Students whose undergraduate GPA is below the 2.5 or 2.8 minimum, are considering courses outside of their current major, are lacking appropriate prerequisites, have completed any prior graduate courses with a grade below a B, or have already completed nine or more credits at the 500 level and above (15 credits for those in the B.S./M.S. program), or have an excessive number of credits for the undergraduate degree will also need approval by the Vice Provost for Graduate Studies.

Undergraduate students should be aware that need-based financial aid may not be sustainable for registration in graduate courses.

Graduate Registration in Undergraduate Courses

To improve their background, graduate students may be asked by their advisor to register in undergraduate bridge courses before they start taking graduate courses. These courses do not count toward the required credits in their program of study. Enrollment in other undergraduate courses requires the approval of the graduate advisor, and the undergraduate department offering the course. Tuition for these courses is assessed at the graduate rate. Grades will follow the undergraduate grading system.

Multiple Program Registrations

A student cannot be matriculated in more than one degree program at a time. This also applies to programs run cooperatively with Rutgers-Newark and RBHS. Currently enrolled graduate students who wish to enroll in a subsequent graduate degree program should not file an application for admission to the new program until they are in the final semester of their initial program.

Graduate Program Change

Graduate students are admitted to one degree program and not to the university as a whole. **Master's students** who wish to change major must file the Graduate Change of Program Form **(**https://www5.njit.edu/registrar/sites/registrar/files/lcms/forms/pdf/GraduateChangeProgram.pdf**)**. Interested students are expected to submit the program change form close to the end of the first semester in their current program. There is no guarantee or requirement that the program change will be approved. Those on financial support are liable to loss of support from the original department and cancellation of a current award. Program changes require the approval of two academic advisors (for the current and future programs). Also, international students may require approval of the Global Initiatives Office. **Ph.D. students cannot apply for program change using the aforementioned form**. Exceptions may be made by the Vice Provost of Graduate Studies in consultation with the graduate advisors,

Adding Courses

Students who add a course to their program will be charged the full tuition and fee for the course added; however, the flat rate (12-19 credits) may still apply. All schedule changes are completed via Highlander Pipeline and a schedule change fee will be assessed during late registration as determined by the Registrar.

Students cannot receive credit for courses if they are not registered. **Attendance in a class without proper registration for that class is not permitted**.

Withdrawal from Courses

Students who wish to withdraw from one or more courses should first determine if the withdrawal would have an impact on their full-time status, financial support, immigration status, or academic standing and progress. They should consult with their advisor. Sometimes their advisor may contact the Office of Graduate Studies to appeal on their behalf (e.g., late withdrawal). International students must consult with the Global Initiatives Office because of the possible impact on their status reported in SEVIS. Withdrawals before the deadline set by the Registrar are completed through Highlander Pipeline. Failure to withdraw by the deadline will result in a final grade other than W.

Discontinued attendance, or verbal approval alone to withdraw, will not result in a W and most likely will instead result in an undesirable final grade, generally an F or U.

Withdrawing from courses does not necessarily lead to a refund and students should consult with their academic and financial aid advisor on the issue before they actually withdraw.

Detailed information on Withdrawal policies can be found at the following link:

https://www.njit.edu/registrar/registration/

Project, Thesis and Dissertation

Students should not register for master's project, master's thesis or Ph.D. dissertation credits until they arrange for a department or program-approved faculty advisor to supervise their work. Continued registration for additional thesis or dissertation credits within the overall time limits for completion may be allowed with approval of the academic and research advisors. A **master's project registration is only for one semester and the incomplete (I) grade cannot be assigned**. Credits for which a U (unsatisfactory) grade is given are not counted as degree credits toward completion of the thesis, project or dissertation. Master's project and master's thesis registration must be at least 3 credits during a semester. Summer session registration, if needed to allow completion for the August 31st degree date, must be at least 3 credits of project or thesis. A procedure is available to determine full-time academic status for master's students (https://www.njit.edu/graduatestudies/full-time-status-ms-students/).

Students who were already enrolled in the Ph.D. program before August 2015 must register for at least three credits of dissertation research each semester in order to accumulate 24 pre-doctoral and doctoral dissertation research credits (20 credits for YWCC students). A student may then register for one dissertation research credit each semester until graduation; a minimum of 36 credits in pre-doctoral and doctoral research courses is needed to meet degree program requirements. **The required doctoral dissertation research credits for students who entered the Ph.D. program after August 2015 are based on** program milestones **(**https://www.njit.edu/graduatestudies/content/new-phd-credit-requirements/**).** A procedure is is available to determine full-time academic status for Ph.D. students (https://www.njit.edu/graduatestudies/full-time-status-phd-students/).

Maximum credit registration each semester is 12 credits for the doctoral dissertation, six credits for the master's thesis and three credits for the master's project. Additional credit registrations will require the approval of the Vice Provost for Graduate Studies. It is highly recommended that the Master's thesis registration be only three credits in a semester unless a single semester completion is anticipated.

Once a student has begun master's thesis or doctoral dissertation work, the student must register for the respective courses each semester until the thesis or dissertation is completed. Unapproved interruptions in thesis or dissertation registrations are subject to billing for omitted credits.

Students must be registered in project, thesis or dissertation in any semester or summer session in which completion is expected. The advisor for thesis or dissertation assigns the final grade of P when the Office of Graduate Studies confirms it has received all documents in final and approved form and all related bills have been paid.

Approval by the graduate program advisor and the Office of Graduate Studies must be obtained if, for extenuating circumstances, the student wishes to interrupt the thesis, project or dissertation for a semester or more. Students may neither maintain registration, nor fail to register without notifying and getting approval from the graduate program advisor and the Office of Graduate Studies. If a master's project is not completed after two semesters of registration (with prior approval of the Graduate Studies Office to repeat the project course), a final grade of F is given. Failure to complete a master's project by students who received financial support to do the project may result in academic dismissal. The university complies with all state and federal laws related to military service.

Although up to two semesters of master's thesis registration is allowed, additional registration requires an appeal of the academic and research advisors to the Vice Provost for Graduate Studies. However, no more than four semesters and two summers of registration for a master's thesis are permitted. Failure to complete a master's thesis within this period will result in a final grade of U and may result in dismissal.

No more than six years of registration for pre-doctoral and doctoral dissertation research is permitted. Failure to complete a doctoral dissertation in this period will result in a final grade of U and dismissal from the program.

All students must have the program advisor's approval and appropriate section identification each time they register for project, thesis, dissertation, pre-doctoral research, co-op, or Independent Study. Students must register within the deadlines established by the Registrar.

Continuous Registration Requirement, Programs

Once admitted to a degree program, students must be continuously registered for credit each semester until they complete all degree requirements, unless they have been approved for a leave of absence.

Continuous Registration Requirement, Thesis/Dissertation

Once a thesis or dissertation has begun, students must register in MS thesis or dissertation research each semester until completion. Maintaining registration is not permitted in place of a credit registration for thesis or dissertation work. **The grade of I is not permitted for the MS thesis or doctoral dissertation courses**.

Students who complete work for thesis or dissertation over several semesters receive a final grade in the semester in which the work is completed, and after approval of the final document by the Graduate Studies Office.

Discontinuance

Domestic students enrolled in graduate programs who find it necessary to temporarily discontinue their studies may either maintain registration, request a leave of absence, or voluntarily discontinue. A discontinuance form must be filed with the Office of Graduate Studies. International students may not discontinue studies without approval from the Office of Global Initiatives, but should seek approval for a leave of absence at which time maintaining registration may be authorized. PhD students may maintain registration only by permission of the Office of Graduate Studies. Students who have discontinued must follow procedures defined by the offices of University Admissions and Graduate Studies to resume their studies.

Leave of Absence

Students who anticipate a protracted absence from the university may request a leave of absence from the Office of Graduate Studies. Students requesting a leave of absence for medical reasons will be required to consult with the Dean of Students office first. Leaves are granted for up to one year and may be extended for a second year. Leaves of absence are not counted toward the time limit in which the degree must be completed, but rules regarding expiration of credit do apply for course work, MS project, MS thesis and doctoral dissertation research. Students returning on-time from an approved leave of absence are generally not required to apply for readmission, but are required to inform the Office of Graduate Studies on their return. International students may be required to apply for readmission and file new financial documents. They also are required to consult with their graduate advisor. The university complies with all state and federal laws related to military service.

To All Students, Advisors and Faculty

The university continues to make every effort to protect student's academic and personal information. Moreover, maintaining the confidentiality of student's medical information is a legal and ethical duty, as defined by federal and state laws and regulations, and by the courts. Whenever students have a personal situation that affects their academic standing, it should be brought to the Dean of Students. This includes medical or psychological documentation to support a student's claim. Students should not bring such information to their instructors, nor should it be requested by a faculty member. The Dean of Students has staff to evaluate such information to verify its legitimacy. The Dean of Students will then notify the faculty member(s) if a student has a legitimate absence and will ask that the student receive consideration in making up any missed course work or exam. This process ensures student privacy and, just as important, consistency in dealing with such matters.

Readmission After Voluntary Discontinuance

Students who have voluntarily discontinued their studies without receiving a leave of absence, and who have not been dismissed from an NJIT graduate program, must apply for readmission to the Office of University Admissions by the application deadline. A non-refundable application fee must accompany applications. Applicants are subject to all probationary and unmet conditions in force at the time they discontinued their studies. Program requirements at the time of readmission will apply in addition to satisfaction of any prior unmet conditions.

Maintenance of Registration

Students enrolled in a degree program who find it necessary to temporarily discontinue their studies are permitted to maintain registration with approvals as noted above, for a fee for each semester they do not register and for a maximum of two consecutive semesters. Students working on a MS project, MS thesis or doctoral dissertation are generally not permitted to register for maintaining registration. International students on F-1 and J-1 visa status may not maintain registration unless they have obtained prior written permission from the Global Initiatives Office.

Students who maintain registration are mailed registration notices for the following semester and are not required to reapply for admission. After receiving approval to maintain registration, students must register for "Maintaining Registration" on the course registration website.

Each semester in which registration is maintained is counted in the total time period allotted to complete degree requirements except for students with an approved leave of absence. Generally registration holds are placed on students who maintain registration for two semesters or more.

Responsibility for Registration

NJIT emails notices in advance, but cannot guarantee delivery. Regardless, students are expected to obtain all necessary information and comply with all registration procedures on time.

Scheduling of Classes

Graduate courses are, in general, scheduled for late afternoon and evening hours. Special programs, such as the Executive Management and some online programs, have their own schedules.

Course Cancellations

The university does not guarantee offering all or any of the courses listed in this catalog. When there is inadequate registration, a course may be canceled without notice. The Registrar will attempt to notify all students of course cancellations before the first meeting of the semester.

Room Changes

Room and laboratory changes are in the online schedule maintained by the Registrar via ***Highlander Pipeline***.

Courses Taken at Other Colleges

Cross-Registration Procedures

Students may take courses at Rutgers-Newark provided that the:

- Course is used toward a degree.
- Course is not offered at NJIT, or, because of a conflict in schedule, cannot be taken at NJIT.
- Approval is obtained, in advance, from the student's advisor.
- Approved cross-registration form is submitted by the student to the host school. The course must also be included on the NJIT registration form.

Students in joint programs should register at the school that admitted them to their current degree program. Students from Rutgers-Newark must be matriculated in graduate programs at their home institution to cross-register for NJIT courses. Students from Rutgers-Newark who cross-register into NJIT are considered NJIT non-matriculated students and are therefore limited to 9 credits maximum. In order to take more than 9 credits, these students would have to apply and be admitted as matriculated students for an NJIT graduate degree program.

Summer course registration procedures, and inclusion of courses on NJIT transcripts for students wishing to take courses at Rutgers-Newark, are determined by the Transfer of Credits policy outlined below. In general, cross-registration cannot occur for summer sessions.

Registration at Another College

To take graduate courses at colleges other than those in the cross-registration program or during the summer sessions at Rutgers-Newark, students must obtain prior approval from their advisor and the Office of Graduate Studies. Students should review the section on **"Transfer of Credits"** if they wish to transfer these courses to an NJIT program. Tuition remission from NJIT is not available for courses taken at educational institutions not participating in NJIT's cross-registration program.

Transfer of Credits

Transfer credits are calculated by NJIT according to the total number of instructional minutes earned at the other institution. The equivalent instructional minutes of a maximum of 9 credits of graduate work, taken within seven years, from accredited US educational institutions may be transferred and applied to degree requirements at NJIT. Credits from educational institutions outside the United States (except Canada) cannot be transferred as individual courses. The university does not grant transfer credit for work experience or other non-instructional activities.

Groups of courses may sometimes be accepted as a block of credits toward some types of programs. Subject to specific MBA program conditions, an equivalent block of 12 credits can be accepted from a graduate degree previously awarded by a US AACSB accredited management program or internationally from a program accredited by AACSB or an AACSB-affiliated accrediting agency. For the MBA program, the proposed block must be based on courses with grades of B or better and on courses with equivalent credit values of 3 or more credits

Credits are transferred only if the courses were taken for full academic credit, were never applied to any other degree, and a final grade of at least B (3.0 GPA equivalent) was attained. In addition, the student's graduate advisor and the Office of Graduate Studies must agree that such courses directly relate to the student's program of study at NJIT before they can be transferred.

Requests for transfer credit must be submitted on a form available from the Office of Graduate Studies, accompanied by course descriptions from the other educational institution. Students must also arrange for the other institution to send an official transcript to the Office of Graduate Studies at NJIT. Requests may be submitted and approved at any time but are not added to a student's record until matriculation is granted and one semester completed. Grades that are transferred will not be calculated in cumulative GPAs.

Transfer of Credits Within NJIT

A student may transfer credits from one program to another program within NJIT under certain circumstances. This type of transfer requires consultation of the advisor with the Office of Graduate Studies but does not require completion of a transfer credit form or submittal of NJIT transcripts. All graduate credits taken at NJIT, regardless of the major, appear on a general transcript.

Responsible Conduct of Research (RCR) course

INTD 799, the 0-credit RCR course, must be taken by all PhD students in their first year of studies. Master's students registering for the first time in Master's Thesis (commonly a 701B or 701C course) or Master's Project (commonly a 700B course) must take simultaneously this RCR course. Students learn in this online course how to maintain high standards in professional integrity and ethics while working on research projects. The course focuses on such topics as conflict of interest, research and ethics, plagiarism, reproducibility of results, research misconduct, authorship, and data management. To receive the satisfactory (S) grade, a student must be awarded the course completion certificate.

Academic Standing

Enrollment Status

Students registered for 9 credits or more in a semester are considered full-time. Also, PhD students and MS students completing an MS thesis may be considered full-time under certain conditions. Please, contact the Graduate Studies Office or visit its website (https://www.njit.edu/graduatestudies/full-time-status-ms-students/) for further details. International students must be in full-time status every semester. The Office of Global Initiatives will report, in SEVIS, international students who meet the full-time definition under F-1 regulation 8CFR 214(f)(6). Any international students unsure of their status should contact the office at 973-596-2451 or e-mail to global@njit.edu. Students who are not registered for 9 credits and do not meet the conditions for full-time certification are considered part-time.

Full-time Certification

The Office of Graduate Studies may certify students as full-time even if they are not registered for 9 credits, under any of the following circumstances:

- If a master's thesis registration is included in a prior semester, an additional semester (maximum of two semesters) with only a master's thesis registration is acceptable. The student must be in good academic standing.
- Students have fewer than 9 credits remaining for completion of all degree requirements and are registered for all credits needed to complete the degree. This certification can only be given for one semester.
- Doctoral candidates who completed all required course work and meet the minimum dissertation registration requirements as per NJIT's outlined policy (see below).
- Students originally registered for 9 credits but have substantial extenuating circumstances that require a reduction in course load. Normally this certification applies only in cases of medical or similar emergencies that incapacitate a student for a significant part of a semester. Improper course registration, failure to seek proper advisement, inadequate academic progress, or risk of earning a weak or failing grade are not extenuating circumstances. Inability of an international student who had earlier filed a financial attestation to pay tuition and fees, is also not an extenuating circumstance.
- Students on a full-time cooperative education assignment are registered in a graduate co-op work experience or equivalent course. The Office of Graduate Studies should be consulted for limits on cooperative education because cooperative education has an influence on full-time certification and allowable time to complete the degree.
- Audited courses and withdrawn courses do not count toward full-time status; ESL (English as a Second Language) courses may not count as one course each.

Half-time Students

For federal, financial aid, and other reporting purposes, half-time graduate student status may be defined for students registered for 6 credits or fewer during a semester. Contact the Office of Graduate Studies for more information.

Grades

The following grades are used for graduate courses:

Grade	GPA	Significance
A	4.0	Excellent
B+	3.5	Good
B	3.0	Acceptable
C+	2.5	Marginal Performance
C	2.0	Minimum Performance
F	0.0	Failure
I		Incomplete
W		Approved Withdrawal
AU		Audited (no academic credit)
S or U		Satisfactory or Unsatisfactory
P		Passing for Master's Thesis or Doctoral Dissertation

P	Pass*
AC	Academic Credit*
NAD	Non-Academic Credit*

Pass/Academic Credit/Non-Academic Credit - In Spring 2020 only. Due to the COVID-19 pandemic and transition to completely online classes, NJIT allowed students to elect to have grades converted to: P (PASS-may be used toward the degree), AC (Academic Credit-may be used toward the degree) or NAD (Non-Academic Credit - may not be used toward the degree). None of these grades affects the term or cumulative GPA.

(Unlike undergraduate courses, there is no D grade for graduate courses. Assigned grades must be consistent with the level of the course and not the matriculation level of the student in the course. Grades used in GPA calculations (A, B+, B, C+, C, and F) are not to be used as grades for dissertation research (790), pre-doctoral research (792), master's thesis, 0, 1/2, and 1 credit seminars, co-op, teaching methods, and ESL courses. Incompletes are not assignable for these courses with the exception of co-op as described later.)

Grades in MS Project, MS Thesis and Doctoral Dissertation

Grades for these courses are S or U until completion. Students who do not complete a thesis or dissertation in a semester, regardless of accumulated credits, must register again for 3 credits of thesis, or at least 1 credit of dissertation (per program requirements) in the following semester.

Letter grades bearing on the GPA are given for satisfactory completion of an MS project. The final grade for a completed and approved thesis or dissertation is P. Theses and dissertations require a successful defense before a thesis or dissertation committee as well as submission of the final thesis or dissertation documents to the Office of Graduate Studies, after which the P is assigned by the research advisor.

Semester and cumulative GPA calculations by the Registrar only include courses for which a letter grade is given. Letter grades cannot be given for work not submitted. Receipt of two U grades for project, thesis, dissertation, or pre-doctoral research can result in dismissal from the program.

Special Topics

Regular letter grades are assigned for special topics courses.

Independent Study

Regular letter grades are assigned for Independent Study (normally numbered 725 and 726) courses.

Incomplete

A grade of I (Incomplete) is given when courses cannot be completed because of special circumstances. Students on academic probation are not permitted a grade of Incomplete without permission from the Office of Graduate Studies. Required course work may be finished at the discretion of the instructor, no later than the end of the subsequent semester. Receipt of an I does not require or suggest attendance in the course in the following semester. A letter grade must be assigned by then or a grade of F will be automatically assigned. Students nominated for financial awards must have I grades resolved by the fourth week of the subsequent semester to allow a determination of their eligibility for the award. The new grade cannot be changed.

A grade of I cannot be given for thesis, project, dissertation, seminar, pre-doctoral research, or English as a Second Language (ESL) courses. Students in joint programs or cross-registered from Rutgers-Newark should note that NJIT has a different and much earlier deadline for resolution of I's before they automatically become F's. Some departments may assign an initial I for co-op courses, which may be changed to an S or U based on submittal of a report by the student to the co-op advisor. Students continuing for a second consecutive registration period in co-op with the same employer will have an I assigned as a grade for the first registration. This will be changed to S or U, based on co-op performance and evaluation by the co-advisor at the end of the second registration period.

Satisfactory and Unsatisfactory

The grades S and U report progress in project, thesis, dissertation, and pre-doctoral research courses. These also can be final grades in seminar, co-op, teaching methods and ESL courses. The grade of S is given for satisfactory progress and U is given for unsatisfactory progress. Students who fail to meet with the instructors of these courses or do not satisfy relevant attendance requirements will receive a U grade. Credits for courses in which U is received cannot count toward a degree.

Grade Reports

The Registrar no longer issues grade reports. Grades may be viewed using a confidential password and identification number at http://www.njit.edu/registrar (http://www.njit.edu/registrar/), the registrar's home page.

Grade Changes

Grade change requests will not be accepted after the end of the subsequent semester. Students should carefully monitor their records and contact the Registrar or the Office of Graduate Studies about any missing or incorrect grades no later than the end of the following semester.

Grade Disputes

Students are expected to resolve disputes about grades with their instructors. If they cannot reach a satisfactory settlement with their instructor, students are permitted to request the intervention of the chairperson of the department. NJIT's grade appeal policy is available at the Office of the Provost's website.

Course Repetition

A maximum of two courses may be repeated in matriculated graduate study. The grade received in a repeated course is calculated in the cumulative GPA, but the first grade still appears on the transcript. Students may not repeat a course without prior approval from the department. Non-matriculated students, including certificate students, may repeat a maximum of one course. Students who receive an F in a course will be required to repeat that course.

The academic advisor may contact the Vice Provost for Graduate Studies if the course is no longer offered or not applicable to the student's current program, or other extenuating circumstances are believed to exist.

Progress Toward Degree

Academic Performance and Satisfactory Progress Policy

Students must maintain satisfactory progress in working toward a degree. Federal and state regulations governing financial aid and awards require that students receiving aid from government agencies must meet academic performance and progress requirements defined by the university and approved by the appropriate government agencies.

NJIT reviews the academic standing of all graduate students at the end of each semester. To have satisfactory academic standing, students must have a cumulative GPA of 3.0 or higher, must have a GPA in two consecutive semesters of 3.0 or higher, must meet all university requirements and must be making satisfactory progress toward a degree. Students who do not have satisfactory academic standing are subject to academic warning, academic probation or academic dismissal.

Academic Warning

Students who have completed at least one full-time semester (or its equivalent of 9 credits) and do not have satisfactory academic standing should meet with their graduate advisor to review their academic record.

Academic Probation

Students who have completed at least 9 credits and do not achieve satisfactory academic standing may be placed on academic probation or be subject to dismissal. Conditions for continuing graduate study at NJIT are sent to students on academic probation. The academic advisors will work with students to determine approaches toward successful program completion. Academic probation is noted on the permanent academic record. Students on probation for two consecutive semesters are subject to dismissal from the graduate program.

Dismissal

Students may be dismissed from graduate gtudies for cause at any time. Cause shall include, but is not limited to:

- Failing to meet the conditions of admission.
- Failing to maintain a cumulative GPA of at least 3.0 after completing one semester or attempting at least 9 credits.
- Failing to make satisfactory progress toward a degree.
- Failing to meet the requirements for graduation.
- Failing a required or repeated course more than once.
- Failing to satisfy requirements for project, thesis, or dissertation within the required time limits.
- Failing doctoral qualifying and similar examinations required for continuing studies in the program, or failing to take examinations within prescribed time limits.
- Professional conduct offenses as defined in the NJIT Code of Professional Conduct.
- Making a false representation relating to admission, registration, or the awarding of financial support.
- Failure to pay all tuition, fees and other charges within the required time limits.

Dismissal is noted on the permanent academic record.

Decisions relating to a graduate student's academic status are made in accordance with regulations approved by the faculty and its standing committees.

Students who disagree with a decision should attempt to resolve the matter with those immediately responsible. When a matter cannot be resolved at this level, students should appeal to the Chairperson of the department and then to the Dean of their school or college.

Readmission if Dismissed

Students dismissed from NJIT for academic reasons may apply for readmission to another degree program after at least one calendar year.

Dismissed students who seek readmission should apply to the Office of University Admissions at least two months before the date of intended readmission. These students must complete, in full, the application for admission and provide all requested documentation, regardless of previous applications. Readmission is treated as a new application. Readmits compete against all other applicants for admission that semester. The circumstances and conditions of the dismissal will be considered in the readmission process.

Students dismissed for professional conduct offenses or for making false representation will not be readmitted to NJIT.

Students who reapply should also include supportive material to justify readmission. Such material may include, but may not be limited to, scores obtained in the GRE or GMAT, grades obtained in graduate level work at other institutions, letters of recommendation, and a statement by the applicant. A non-refundable fee must accompany applications.

General Graduate Degree Requirements

Graduate degree candidates must achieve a cumulative GPA of at least 3.0 in all graduate-level courses (500 level and above) and satisfy other academic and non-academic requirements. These include financial obligations to the university. Students whose programs require a thesis or dissertation must complete these within time limits and policies prescribed by the Office of Graduate Studies. Master's theses and doctoral dissertations must be submitted for final approval to the Office of Graduate Studies. Master's projects need to be submitted only to the advisor.

At least three program approval signatures are required for master's theses; at least five are required for doctoral dissertations (at least four signatures are required for the Urban Systems program). Fees that must be paid include, but are not limited to, the binding fee, publishing fee, copyright fee.

Grade Point Average Calculation

GPAs are calculated for each semester and cumulatively for the entire graduate record. In order to obtain a graduate degree, candidates must have a cumulative GPA of at least 3.0 when considering all graduate-level courses. All 500 level (500G for Architecture) or higher graduate courses are included in the cumulative graduate GPA. Only the initial grades for graduate courses that have been repeated (with a maximum of two allowed) are excluded from GPA calculations. Undergraduate credits taken by graduate students are not counted. Some programs also may require a 3.0 GPA in designated core course requirements.

In addition, the cumulative GPA for all courses counted for the degree must be 3.0 or better. Grades for the master's project must be B or better. Successful completion of a master's thesis or doctoral dissertation, along with defense, will be assigned a grade of P for passing. The P grade is for the thesis or dissertation credits taken in the student's final semester.

Graduation Certification Course Exclusion

Under extenuating circumstances, the graduate student’s academic advisor may suggest the exclusion of specific courses for the calculation of the student’s GPA. These courses will not count for graduation certification and degree requirements. Prior approval of the Vice Provost for Graduate Studies is needed. The required form may be requested only by the advisor by contacting the Office of Graduate Studies and justifying the request.

For students transferring between graduate programs, the advisor must submit the Graduation Certification Course Exclusion form within a month after the student enrolls in the new program.

Theses and Dissertations

Theses and dissertations submitted for graduate degrees must follow a prescribed university format. The approved format is based on the Estrin/Roche manual: Guidelines for Scientific and Professional Theses. The Office of Graduate Studies provides seminars, guidance documents and continuing assistance for students. The office or its website should be consulted for more information.

Degrees cannot be certified until the Graduate Studies Office receives and approves the final thesis or dissertation documents with all related requirements completed. The Graduate Studies Office will notify the advisor and the registrar that these documents have been approved before a final grade of P can be assigned. The NJIT Library posts completed theses and dissertations on the NJIT website and works with the external bindery. Students are notified by the Library about availability of completed and bound theses and dissertations, typically several months after degree completion. The Graduate Studies Office can make arrangements, for a specified period, for sequestering a completed thesis or dissertation for proprietary or patent reasons, if requested by the student and the advisor.

Special Topics

Special Topics courses are occasionally offered by departments to present new areas of high demand where rapid developments in the field have not allowed time for formal approval of such courses. These are announced by the departments in time for registration and are typically well-enrolled. They may be at the master's or doctoral level. There is no university limitation on the number of special topics courses that may be taken.

Independent Study

Independent study is for students who want highly specialized study with a specific faculty member in areas in which specifically titled courses are not normally available. Students should see their advisors regarding independent study options. For students in doctoral programs, a maximum of two independent study courses may be used to partially satisfy the 700-level course requirement. Enrollment in independent study may be as low as one student under a faculty section number.

Expiration of Credit

For all degrees, credits expire seven years after completion of the semester in which they are earned. Expired courses cannot be used to fulfill degree requirements and must be replaced by current credits. Exceptions can be made by the Vice Provost for Graduate Studies after receiving an appeal from the student's academic advisor.

Degree requirements must be generally completed within seven years of original admission. For Ph.D. students entering the program after August 2015, the limit is six years of attendance. Approved leaves of absence do not count against these limits although the validity of individual courses may still expire during the seven-year period. Requests for waivers of the seven-year limit for extenuating circumstances, other than mere failure to register, are made to the Vice Provost of Graduate Studies after receiving an appeal from the student's academics advisor. The technical content and remaining currency of courses is considered in evaluating these requests. The majority of courses in rapidly changing fields are not likely to be accepted after seven years.

Awarding of Degrees

Degrees are awarded three times each academic year: August, December and May. The university conducts its commencement ceremony once per year, normally in May. Candidates for graduation must file an Application for Graduation with the Registrar. The application must be consistent with the student's program of admission and current record. Forms are available at www.njit.edu/registrar (http://www.njit.edu/registrar/). Applications received after the specified deadline are accepted for the requested degree date at the discretion of the Registrar and are subject to a late fee. Unsuccessful applications will be automatically added to the next commencement list and students will be billed for the appropriate fees. This will be done a maximum of three times.

Students who have not completed all requirements for the degree cannot participate (walk) in the May commencement.

Deadline Waiver

Advisors of applicants for the August, December or May degree dates whose master's thesis or doctoral dissertation is substantially complete, but who are unable to submit it in final form by the specified date, may request a deadline extension from the Vice Provost of Graduate Studies. Such students may then apply for the next scheduled graduation without having to pay for additional thesis or doctoral dissertation credits. Advisors should contact the Office of Graduate Studies for further information.

Students who do not meet the deadline waiver will be required to register for master's thesis or doctoral dissertation in the subsequent enrollment period to allow formal completion.

Master's Degree Requirements

NJIT offers Master's degrees in a variety of disciplines through the five degree granting colleges and schools: Newark College of Engineering, College of Science and Liberal Arts, Ying Wu College of Computing, Martin Tuckman School of Management, and College of Architecture and Design. NJIT also offers master's degrees in interdisciplinary areas that may include coursework from a number of colleges or schools. The programs are flexibly arranged to allow new specializations and to allow new programs to be developed in response to changing needs. All current programs are listed in another section of the catalog. Students seeking more than one Master's degree should consult the Office of Admissions and the Office of Graduate Studies. There are options available that can reduce the time and number of credits for completion of the second degree.

Most master's degree programs require a minimum of 30 credits to complete. Some master's degree programs, particularly those in professional areas, require additional credits beyond 30 credits. Specific program sections of the catalog describe these requirements. In general, courses for master's programs must be numbered at the 600 level or above; some programs will allow up to two courses numbered 500-599. Some programs may also require a master's thesis or a project.

Up to 9 credits from outside NJIT, subject to approval by the advisor and the Graduate Studies Office and based on NJIT transfer credit policies described elsewhere, may be applied to master's degrees. Generally, NJIT does not allow transfer of credits already used as part of the credit requirements for a prior degree awarded by another university. However, students who have completed a master's degree elsewhere that includes more than the typical 30 credits for a master's degree and are considering an NJIT master's degree that also includes much more than the typical 30 credits, such as an MBA or an MArch degree, will be considered for a block transfer of up to 12 credits from the prior degree toward the NJIT degree. These types of transfer will require approval of the advisor and the Vice Provost for Graduate Studies.

Bridge Program

Students who seek a master's degree in an academic discipline different from that of the bachelor's degree may be admitted to a master's degree program but may be required to complete appropriate undergraduate and/or graduate prerequisites in addition to the normal graduate degree requirements of the program. The program of courses will be individually designed in consultation with their graduate advisor. Bridge courses must be completed before 9 credits of graduate degree courses are earned. Bridge courses are not counted as degree credits but do count in graduate GPA calculations if the course is numbered 500 (500G for Architecture) or higher.

Master's Thesis Advisor, Committee, and Defense

A master's thesis committee should be formed at the start of the second semester of thesis registration (or at the start of the first semester if a single semester completion seems certain). The committee must have at least three members. All members of the committee must hold faculty rank.

The chair of the committee must be a tenured or tenure track faculty member in the department or program offering the degree. At least one other member of the committee must hold a tenure-track position or be a research professor in the department or program offering the degree. The Guidelines for Graduate Faculty membership at NJIT must be followed (http://www5.njit.edu/provost/grad-study/) when forming a committee. Approval of the committee is made by the program director and reported to the Graduate Studies Office on a standardized thesis committee appointment form.

The thesis defense must be defended in a public forum. Successful defense of the thesis is determined by vote of the thesis committee. The committee members must be present at the defense. Every member of the thesis committee must sign and date the approval page of the final thesis document. A report on passage, conditional passage, or failure of the defense is completed by the thesis committee chair, signed by the thesis committee members, and sent to the Graduate Studies Office on a standardized form.

Ph.D. Degree Requirements

Detailed descriptions of the degree requirements for specific degrees or degree/discipline combinations may be found in the Degree Programs section of this catalog.

PhD degree requirements for students entering a Ph.D. program after August 2015

1. Ph.D. coursework registration requirements

Ph.D. students with a recognized Master’s degree or equivalent are required to take four 700-level 3-credit courses (12 credits). Ph.D. students with a recognized Baccalaureate degree are required to take eight 600-level or 700-level 3-credit courses (24 credits) of coursework beyond the Baccalaureate degree as well as four additional 700-level 3-credit courses (12 credits), for a total of twelve 3-credit courses (36 credits). Master’s project (course 700), Master’s thesis (course 701), or more than two independent study courses (courses 725 and 726) cannot be used to satisfy these coursework requirements. A Ph.D. student may substitute a 600-level course for a 700-level course only after the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. program may define an additional set of required courses that must be pre-approved by the academic college (multiple colleges may be involved for interdisciplinary programs). Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.

2. Ph.D. dissertation registration requirements

- Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (792B) per semester until they defend successfully the dissertation proposal.
- Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (790A) each semester until they complete all degree requirements.
- Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.
- Students who do not meet the following deadlines will be dismissed from the Ph.D. program.
    - The required coursework for the Ph.D. program and the (major part of the) QE must be completed successfully by the end of the second year in the program.
    - The dissertation proposal must be defended in a public forum successfully either by the end of the third year in the Ph.D. program or four semesters after registering for the first time in the 792 pre-doctoral research course, whichever occurs earlier.
    - The dissertation must be defended successfully by the end of the sixth year in the Ph.D. program.

(Note: The credit requirements for any joint Ph.D. program, for which the names of multiple universities appear on the diploma, follow the explicit requirements of the joint program.)

PhD degree requirements for students entering a Ph.D. program before August 2015

The number of credits required for completion of doctor of philosophy degrees varies with the program and the level of entry into the program. Students holding a prior master's degree generally require a minimum of 60 graduate credits beyond the master's degree (which is assumed to have included at least 30 graduate credits beyond the bachelor's degree). Students entering the doctoral program with a bachelor's degree and who do not wish to complete a master's degree while pursuing the doctoral degree will be required to complete a minimum of 84 graduate credits beyond the bachelor's degree for programs offered by the Newark College of Engineering and 78 graduate credits beyond the bachelor's degree for programs offered by the College of Science and Liberal Arts.

Students who enter an NJIT doctoral program with two or more master's degrees already completed or a large number of appropriate prior graduate credits may be considered for a reduction in the credits required at NJIT. The evaluation of the requirements will be made by the program advisor in consultation with the Associate Provost for Graduate Studies. The minimum credit requirement for the doctoral degree at NJIT is 36 dissertation research credits, regardless of any other requirement waiver.

Doctoral program credit requirements for joint programs for which the names of multiple universities appear on the diploma, are to follow the requirements of the program as approved by the universities, generally a minimum of 72 credits beyond the bachelor's degree.

In addition to overall credit requirements, each program includes the following minimal requirements:

- For those entering the program with master's degrees, 24 credits of course work beyond the master's degree of which at least 12 credits must be at the 700 level and none at the 500 level or lower.
- For both entry levels; baccalaureate or master's start-point, at least 12 credits of course work at the 700 level; no more than two independent study courses may be used to satisfy this requirement. master's project or thesis cannot be used to satisfy this requirement.
- 36 credits minimum of doctoral dissertation research for programs offered jointly with other universities.
- 30 credits minimum of doctoral dissertation research for the programs offered by the College of Computing Sciences.
- Dissertation research credits in accordance with the program approval documents for programs offered jointly with other universities.
- Seminar attendance each semester or as required by the program. Nominal credit values, if any, for registration in seminar do not count toward fulfillment of overall credit requirements.

Students who wish to complete a master's degree while pursuing a doctorate in the same field must be approved for this by the doctoral department, the Associate Provost for Graduate Studies, and the director of graduate admissions, and satisfy all requirements for the master's degree, including any thesis or project requirement. In general, such permission is given only after passage of the research proposal exam or if the student is near completion of the doctorate. Students in doctoral programs initially, who terminate their studies at the master's level, will lose further eligibility for support.

Qualifying Examination

Students must pass a qualifying examination within two years of being admitted into a doctoral program. Students are only permitted to take the examination twice. The passage of qualifying examinations is reported to the Office of Graduate Studies on the Qualifying Examination form. Each department determines its own policies with regard to format, grading, and review of examinations by faculty and students. Students are, at their request, permitted to view their examination papers in the presence of a designated faculty member and to see correct examination answers.

Dissertation and Pre-Doctoral Research Credits for Students Already Enrolled in the Ph.D. Program Before August 2015

Students who entered the Ph.D. program before August 2015 may register for doctoral dissertation credits (course number 790) only after passage of the qualifying examination. They may register for a maximum of 6 credits of pre-doctoral research (course number 792) prior to passage of the qualifying exam. These credits may count toward the required number of dissertation credits for the degree. Dissertation and pre-doctoral dissertation credits are graded as S or U except that P is assigned to the last registration for doctoral dissertation upon completion of the degree.

Dissertation Advisor, Dissertation Committee and Research Proposal

Doctoral students with a prior master's degree must choose their dissertation advisor(s) by the fourth semester in the program at the latest. Students without a master's degree must make the decision by the end of the fifth semester. (Different program requirements may apply for Ph.D. programs offered jointly with other universities.)

The department chairperson or doctoral program director is responsible in the student's department/program for approving originally the formation of dissertation committees. The committee must be finally approved by the Vice Provost for Graduate Studies. The Guidelines for Graduate Faculty membership at NJIT must be followed when forming a committee (http://www5.njit.edu/provost/grad-study/). The committee consists of a minimum of five members (four for the Urban Systems program), one of whom is external to the program or to NJIT. The majority of the committee members are tenured or tenure-track faculty from the student's program or department having research experience or developing research interests related to the dissertation research. The dissertation committee chairperson typically is the doctoral candidate's dissertation advisor, but other faculty may be selected, provided they are from the student's program or department. The dissertation committee chair must be a tenured or tenure-track faculty member in the program. Two committee members, including an external member, may serve as co-advisors. The advisor or at least one of the co-advisors must be a tenured or tenure-track faculty member from the program.

Former students of any committee member, who are less than four years beyond doctoral completion, are specifically excluded from membership. The external committee member should either have appropriate faculty rank elsewhere or have sufficient research expertise to warrant inclusion on the dissertation committee.

Part-time doctoral students pursuing the doctorate with industry collaboration (i.e., collaborative Ph.D.) may have at least one dissertation committee member from the participating industrial partner whose research credentials would otherwise be appropriate for a member of the university faculty.

Committees for joint doctoral programs with other universities shall either follow these policies or the specific policies for the joint program consistent with the program approval and related documents.

Each doctoral program has specific requirements for preparing, presenting and accepting proposals. The dissertation defense is expected to be presented in a public forum. Research is expected to investigate or develop a unique contribution to science and technology. Research may be experimental, analytical, applied, or theoretical, provided it satisfies this criteriion and is approved by the dissertation committee. It should be of a quality to warrant scholarly presentation or paper submission to reputable journals in accordance with program practice.

Residency

Doctoral candidates must spend at least one academic year in full-time residence. This requirement is sometimes waived with the approval of the dissertation committee and the Vice Provost for Graduate Studies. Such waivers are granted when a candidate's dissertation research requires use of research facilities at an approved off-campus site. A typical example for residency requirement waiver would apply in the case of students in the collaborative doctorate option.

Doctoral Candidacy

Doctoral candidates are doctoral students who have completed all other requirements for the degree except the completion of the dissertation and the defense. This includes, as a minimum, passage of the doctoral qualifying examination, approval of the research proposal and completion of all course work. Status as a doctoral candidate does not imply candidacy for the degree. A degree candidate will be both near degree completion and have made a formal degree application for a particular graduation date.

Dissertation and Defense

The dissertation should be a scholarly publication of the quality to warrant conference presentation or paper submission to reputable journals. The dissertation must be defended in a public announced oral defense. Successful defense of the dissertation is determined by vote of the dissertation committee. All members of the committee must be present to hear the defense.

In regard to dissertation format, the standard reference is the latest edition of the *Estrin/Roche Manual: Guidelines for Scientific and Professional Theses*. Office of Graduate Studies policies on number of copies, document submission deadlines, fee payments, information documents, and grade submission for acceptance of the final dissertation and for doctoral degree certification are to be followed. The Office of Graduate Studies provides guidance and assistance to students working on formatting their dissertation. Students should contact the office for appointments early in the final semester. The review of format should proceed well in advance of final document approval and dissertation defense.

The dissertation defense must be defended in a public forum. Successful defense of the dissertation is determined by vote of the dissertation committee. The committee members must be present at the defense. Every member of the dissertation committee must sign and date the approval page of the final dissertation document. A report on passage, conditional passage, or failure of the defense is completed by the dissertation committee chair, signed by the dissertation committee members, and sent to the Graduate Studies Office on a standardized form.

Residency Policy for International Students

During the academic year, all international students are required to live within commuting distance to campus, at the local address that they have reported to NJIT. Exceptions to the rule are:

1. A student is on a trip when the school is not in session (e.g. spring or summer breaks).
2. A student is away for academic reasons and with the permission of the student’s advisor.
3. A student has received NJIT’s official approval for out-of-state CPT and is registered in the CPT course.

Graduate students: NJIT considers dissertation and thesis credit classes to be face to face. When graduate students are taking only dissertation/thesis credit with full time certification, they must report to their advisors regularly.

If international students must travel for an extended period of time or live outside of commuting distance to NJIT in order to conduct research or gather data, the students' advisors (dissertation or thesis advisor in the case of doctoral and Master’s students) must be able to, upon request from the Office of Global Initiatives, describe the academic reasons for the students' distance. Writing drafts of dissertation/thesis are not considered academic reasons. If international students must travel internationally to conduct research or gather data, they must report this to the OGI since this can affect their F-1 status.

International students who do not have regular face to face meetings with their advisors can be in violation of their F-1 status and therefore are at risk of having their SEVIS records terminated.

Graduate Certificate Requirements

Certificates require completion of at least 12 specified credits with a GPA of 3.0 or better. Only one course repetition is permitted for certificate students to improve their GPA. The cumulative GPA of the entire graduate record must be at least 3.0 if the student also pursues a relevant master's degree.

Graduate certificate credits may be applied to a relevant master's degree. Dual use of credits from a completed first master's degree to a second and following certificate is not permitted.

Students in certificate programs are usually considered to be non-matriculated students for the duration of the certificate program. Graduate certificate programs are normally completed before students are admitted to a following matriculated master's program. Students who did not apply for admission to a certificate program initially and instead complete the certificate requirements as part of a completed graduate degree program may be permitted to receive a certificate also with approval of the Vice Provost for Graduate Studies.

Preferred Name Policy*

NJIT recognizes that students may wish to be addressed by a name other than their legal name to identify themselves. For this reason, the university now allows students to apply for a preferred name where reasonably possible in the course of university business and education.

In order to initiate this process, a student must submit a Preferred Name Change form with the Office of the Registrar; the application of a preferred name may only be requested once an academic year and must be completed at least one week before the start of the next academic semester. Depending on time of application, it may take several days for the preferred name to appear on university rosters.

Once a preferred name application has been approved, students may proceed to use the preferred name to identify themselves. Please note that some records may require the use of legal names only, such as Financial Aid and/or medical documentation. Students who are utilizing a preferred name should always be prepared to reference their legal name as well as provide their college identification when necessary.

NJIT reserves the right to decline or revoke an approved preferred name on the grounds the preferred name may be used for criminal or misrepresentation purposes, may be harmful to the reputation or interests of NJIT, and/or conveys inappropriate or offensive language or meaning. In the rare circumstance when a denial is made, the student may appeal the decision in writing to the Registrar. The Registrar will provide the appeal to the Dean of Students and Campus Life to reconsider the request and the denial. Abuse or misuse of this policy and process may result in disciplinary action under the Code of Student Conduct.

Students requesting a preferred name under the age of 18 must submit written permission from a parent/legal guardian in addition to a Preferred Name Change form.

Note: Students who have completed a legal name change must fill out a Request to Change Student Name (https://www.njit.edu/registrar/sites/registrar/files/lcms/forms/updatedName%20Change.pdf) form with the Office of the Registrar.

Preferred Name Will Appear:*

- Athletic Team Rosters
- Online directory
- Class rosters
- Commencement programs
- Dean’s List
- Library Records
- Moodle
- Residence Life Rosters
- Student ID Card
- Email display name

*Implementation of these function may vary

Legal Name Will Appear:

- Financial Aid and Billing Records and Communication
- Official and Unofficial Transcripts
- Paychecks & Paystubs
- Registrar’s Office Records (i.e., permanent student file records)

- Study Abroad (i.e., travel documents, signature documents)
- Some official forms or correspondence from the University such as financial aid awards, residence life contracts, departmental or program notices, new hire forms, etc.
- Transfer credit evaluation
- Tax Records
- Diplomas and certifications
- Medical records
- Admissions records
- Disciplinary records
- Law enforcement records

ID Cards

NJIT recognizes it may be important to students for the NJIT Photo Identification Card to reflect ones preferred name. Approved students may request a new ID card with your preferred name from Facility Systems, Photo Identification and Parking Services Department located in the Laurel Hall Annex, on 141 Summit Street (at the corner of Summit and Warren Streets). A one-time $25 ID printing fee will be waived for approved students.

Gender Identity

In addition to a preferred name, students may request their legal gender (i.e., male, female) be removed from their student record.

Process and Implementation

Beginning fall 2018, the university will launch the initial use of the Preferred Name policy as described above. Updates will be communicated to the campus community as the necessary changes are complete to support continued implementation.

Student Privacy Concerns

Consistent with the Family Educational Rights to Privacy Act (FERPA), NJIT allows for the release of directory information, which includes a student’s preferred name. If a student does not want their directory information disclosed to external organizations or persons, they can select "Do NOT show my profile". Members of the NJIT community can however view ones directory information through the "Advanced Search" function. Students can log into the Directory via http://directory.njit.edu (http://directory.njit.edu/).

Students may also request to withhold disclosure of directory information altogether. New Jersey Institute of Technology assumes that failure on the part of any student to specifically request in writing preventing the disclosure of directory information indicates individual approval of disclosure.

Frequently Asked Questions

What is a preferred name?

A “preferred name” is the name other than ones legal name that the student has indicated the desire to be identified by. A “legal name” is the name recorded on the student’s legal identification (i.e., passport, birth certificate, Social Security card) and used on official NJIT records.

Are there any Preferred Name restrictions?

NJIT reserves the right to decline or revoke an approved Preferred Name if the preferred name may be used for criminal or misrepresentation purposes may be harmful to the reputation or interests of NJIT, and/or conveys inappropriate or offensive language/meaning.

When/why will NJIT departments/personnel continue to use my legal name?

NJIT departments, offices, and/or personnel often must use appropriate identification of students’ legal name to conduct university business and functions (i.e., sending reports to federal, State, and other government agencies that require legal identity verification). Students utilizing a preferred name should always be prepared to reference their legal name as well as provide university identification when necessary.

How long will it take for my preferred name registration to take effect?

Depending on the time a preferred name application was submitted to the Office of the Registrar, it may take several business days for the preferred name to begin appearing on certain university rosters. NJIT does not guarantee the preferred name will appear in all locations or in all circumstances.

What if I’ve already received identification with my legal name only?

Students who have already received identification with legal names only may apply for new identification reflecting the approved preferred name.

Will background checks include preferred names?

Students who register a preferred name must be aware that preferred names are required to be disclosed in certain circumstances, including during background checks and other legal processes. The university is under a continued responsibility to report such names even after a student has discontinued use of the preferred name.

Cooperative Education and Internships

Cooperative Education (Co-op) and Internship programs offer students the opportunity, prior to graduation, to gain work experience that is related to their major. The Co-op Program provides students with an experiential and applications approach to education. Co-op is available to matriculated students in all majors. The program enhances the education of the student with the introduction of part- and full-time work experiences during which additive or degree credits can be earned. Co-op enables students to examine a professional field through employment in a major-related job. All co-op students earn a salary that can help defray college and other expenses. The co-op course will be for one credit and included in the student’s bill the first time they register. Any consecutive co-op courses will also be for one credit, but no tuition will be charged irrespective of change of employer. Other fees still apply.

International students only: International students who wish to participate in the co-op experience must apply for employment authorization through the Office of Global Initiatives (OGI) and Career Development Services (CDS). The Office of Graduate Studies reviews requests for all Ph.D. students and deliberates on appeals of MS students whose cumulative GPA is below 3.0. Graduate students can be considered full-time during spring and fall semesters if participating in full-time co-op in addition to at least one (1) face-to-face course. A graduate student participating in part-time co-op must maintain full-time status by registering for a minimum of 9 credits in fall and spring semesters.

Please visit the Graduate Studies Office or if you’re a MS student go to this link (https://www.njit.edu/graduatestudies/full-time-status-ms-students/). (https://www.njit.edu/graduatestudies/full-time-status-ms-students/) If you’re a PhD student use this link (https://www.njit.edu/graduatestudies/full-time-status-phd-students/) for further details.

Degree Programs

College	Department	Degree Level	Discipline	Special Degree Options
SL	Mathematics	Master's	Applied Mathematics - M.S.	
SL	Mathematics	Bachelor's	Applied Mathematics and Applied Physics - B.S.	Double Major
SL	Physics	Bachelor's	Applied Physics - B.S.	
SL	Physics	Bachelor's	Applied Physics - B.S./M.D.	Accelerated
SL	Physics	Master's	Applied Physics - M.S.	
SL	Physics	Doctoral	Applied Physics - Ph.D.	
SL	Mathematics	Master's	Applied Statistics - M.S.	
AD	Architecture	Master's	Architecture (professional or post-professional) - M.Arch. and Civil Engineering - M.S.	Double Major (p. 147)
AD	Architecture	Master's	Architecture (professional or post-professional) - M.Arch. and Infrastructure Planning - M.I.P.	Double Major (p. 152)
AD	Architecture	Master's	Architecture (professional or post-professional) - M.Arch. and Management - M.S.	Double Major (p. 150)
AD	Architecture	Bachelor's	Architecture - B.Arch.	
AD	Architecture	Bachelor's	Architecture - B.Arch. and Civil Engineering - M.S.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.Arch. and Infrastructure Planning - M.I.P.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.Arch. and Management - M.S.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.Arch. and Technology - M.B.A.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.S.	
AD	Architecture	Bachelor's	Architecture - B.S. and Civil Engineering - M.S.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.S. and Infrastructure Planning - M.I.P.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.S. and Management - M.S.	B.S./M.S.
AD	Architecture	Bachelor's	Architecture - B.S. and Technology - M.B.A.	B.S./M.S.
AD	Architecture	Master's	Architecture - M.Arch.	
AD	Architecture	Master's	Architecture - M.S.	
SL	Chemistry & Environmental Sci.	Bachelor's	BioChemistry - B.S.	
SL	Mathematics	Master's	BioStatistics - M.S.	
CC	Computer Science	Bachelor's	Bioinformatics - B.S.	
CC	Computer Science	Master's	Bioinformatics - M.S.	
SL	Biology	Bachelor's	Biology - B.A. • Cell Biology • Ecology and Evolution • Neurobiology	
SL	Biology	Bachelor's	Biology - B.A./M.D., D.M.D., D.D.S., O.D.	Accelerated
SL	Biology	Bachelor's	Biology - B.A./Physical Therapy Ph.D.	Accelerated
SL	Biology	Bachelor's	Biology - B.A./Physician Assistant	Accelerated
SL	Biology	Bachelor's	Biology - B.S.	
SL	Biology	Master's	Biology - M.S.	
SL	Biology	Doctoral	Biology - Ph.D.	
SL	Biology	Bachelor's	Biology and Chemistry - B.S.	Double Major
SL	Mathematics	Bachelor's	Biology and Mathematical Sciences - B.S.	Double Major
EN	Bio-Medical Engineering	Bachelor's	Biomedical Engineering - Accelerated B.S.	Accelerated
EN	Bio-Medical Engineering	Bachelor's	Biomedical Engineering - B.S.	
EN	Bio-Medical Engineering	Master's	Biomedical Engineering - M.S.	

College	Department	Degree Level	Discipline	Special Degree Options
EN	Bio-Medical Engineering	Doctoral	Biomedical Engineering - Ph.D.	
EN	Chemical and Materials Engr	Master's	Biopharmaceutical Engineering - M.S.	
SL	Physics	Bachelor's	Biophysics - B.S.	
CC	Informatics	Bachelor's	Business & Information Systems - B.S.	
CC	Informatics	Master's	Business & Information Systems - M.S.	
SM	Management	Bachelor's	Business - B.S. • Accounting • Finance • Innovation and Entrepeneurship • International Business • Management Information Systems • Marketing	
SM	Management	Doctoral	Business Data Science - Ph.D.	
EN	Chemical and Materials Engr	Bachelor's	Chemical Engineering - B.S.	
EN	Chemical and Materials Engr	Master's	Chemical Engineering - M.S.	
EN	Chemical and Materials Engr	Doctoral	Chemical Engineering - Ph.D.	
SL	Chemistry & Environmental Sci.	Bachelor's	Chemistry - B.S.	
SL	Chemistry & Environmental Sci.	Bachelor's	Chemistry - B.S. for Pre-Professional Students	Accelerated
SL	Chemistry & Environmental Sci.	Master's	Chemistry - M.S.	
SL	Chemistry & Environmental Sci.	Doctoral	Chemistry - Ph.D.	
EN	Civil & Environmental Engr	Bachelor's	Civil Engineering - B.S.	
EN	Civil & Environmental Engr	Master's	Civil Engineering - M.S.	
EN	Civil & Environmental Engr	Doctoral	Civil Engineering - Ph.D.	
SL	Humanities	Bachelor's	Communication and Media - B.A.	
SL	Humanities	Bachelor's	Communication and Media - B.S.	
SL	Humanities	Bachelor's	Communication and Media - B.S./Medicine, Dentistry, Physical Therapy and Optometry	Accelerated
EN	Electrical & Computer Engr.	Bachelor's	Computer Engineering - B.S.	
EN	Electrical & Computer Engr.	Master's	Computer Engineering - M.S.	
EN	Electrical & Computer Engr.	Doctoral	Computer Engineering - Ph.D.	
CC	Computer Science	Bachelor's	Computer Science - B.A.	
CC	Computer Science	Bachelor's	Computer Science - B.S.	
CC	Computer Science	Master's	Computer Science - M.S.	
CC	Computer Science	Bachelor's	Computer Science and Applied Physics - B.S.	Double Major
CC	Computer Science	Bachelor's	Computer Science and Mathematical Sciences, Applied Mathematics - B.S.	Double Major
CC	Computer Science	Bachelor's	Computer Science and Mathematical Sciences, Computational Mathematics - B.S.	Double Major

College	Department	Degree Level	Discipline	Special Degree Options
CC	Computer Science	Doctoral	Computing Sciences - Ph.D.	
CC	Computer Science	Bachelor's	Computing and Business - B.S.	
CC	Computer Science	Master's	Computing and Business - M.S.	
EN	Engineering Technology	Bachelor's	Concrete Industry Management - B.S.	
EN	Civil & Environmental Engr	Master's	Critical Infrastructure Systems - M.S.	
CC	Computer Science	Master's	Cyber Security and Privacy - M.S.	
AD	School of Art & Design	Bachelor's	Digital Design - B.A.	
EN	Electrical & Computer Engr.	Bachelor's	Electrical Engineering - B.S.	
EN	Electrical & Computer Engr.	Master's	Electrical Engineering - M.S.	
EN	Electrical & Computer Engr.	Doctoral	Electrical Engineering - Ph.D.	
EN	Mechanical & Industrial Engr	Master's	Engineering Management - M.S.	
EN	Office of the Dean (NCE)	Bachelor's	Engineering Science - B.S.	
EN		Master's	Engineering Science - M.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Computer Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Construction Engineering Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Construction Management Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Electrical and Computer Engineering Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Manufacturing Engineering Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Mechanical Engineering Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Medical Informatics Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Surveying Engineering Technology - B.S.	
EN	Engineering Technology	Bachelor's	Engineering Technology, Technology Education - B.S.	
EN	Civil & Environmental Engr	Master's	Environmental Engineering - M.S.	
EN	Civil & Environmental Engr	Doctoral	Environmental Engineering - Ph.D.	
SL	Chemistry & Environmental Sci.	Bachelor's	Environmental Science - B.S.	
SL	Chemistry & Environmental Sci.	Master's	Environmental Science - M.S.	
SL	Chemistry & Environmental Sci.	Doctoral	Environmental Science - Ph.D.	
SL	Chemistry & Environmental Sci.	Master's	Environmental and Sustainability Policy - M.S.	
EN	Mechanical & Industrial Engr	Master's	Healthcare Systems Management - M.S.	
SL	History	Bachelor's	History - B.A.	
SL	History	Bachelor's	History - B.A./D.P.T.	Accelerated

College	Department	Degree Level	Discipline	Special Degree Options
SL	History	Bachelor's	History - B.A./J.D.	Accelerated
SL	History	Bachelor's	History - B.A./M.D., D.M.D., D.D.S., O.D.	Accelerated
SL	History	Master's	History - M.A.	
CC	Informatics	Bachelor's	Human-Computer Interaction - B.S.	
AD	School of Art & Design	Bachelor's	Industrial Design - B.S.	
EN	Mechanical & Industrial Engr	Bachelor's	Industrial Engineering - B.S.	
EN	Mechanical & Industrial Engr	Master's	Industrial Engineering - M.S.	
EN	Mechanical & Industrial Engr	Doctoral	Industrial Engineering - Ph.D.	
CC	Informatics	Bachelor's	Information Systems - B.A.	
CC	Informatics	Master's	Information Systems - M.S.	
CC	Informatics	Doctoral	Information Systems - Ph.D.	
CC	Informatics	Bachelor's	Information Technology - Accelerated B.S. and J.D.	Accelerated
CC	Informatics	Bachelor's	Information Technology - B.S.	
CC	Informatics	Master's	Information Technology and Administration Security - M.S.	
AD	Architecture	Master's	Infrastructure Planning - M.I.P.	
AD	School of Art & Design	Bachelor's	Interior Design - B.A.	
EN	Electrical & Computer Engr.	Master's	Internet Engineering - M.S.	
SL	History	Bachelor's	Law, Technology and Culture - B.A.	
SM	Management	Master's	Management - M.S.	
SM	Management	Master's	Management of Technology - E.M.B.A.	
SM	Management	Master's	Management of Technology - M.B.A.	
EN	Mechanical & Industrial Engr	Master's	Manufacturing Systems Engineering - M.S.	
SL	Physics	Master's	Materials Science and Engineering - M.S.	
EN	Chemical and Materials Engr	Master's	Materials Science and Engineering - M.S.	
SL	Physics	Doctoral	Materials Science and Engineering - Ph.D.	
EN	Chemical and Materials Engr	Doctoral	Materials Science and Engineering - Ph.D.	
SL	Mathematics	Bachelor's	Mathematical Sciences - B.S. • Mathematical Biology • Mathematics of Finance and Actuarial Science • Applied Mathematics • Applied Statistics and Data Analysis • Computational Mathematics	
SL	Mathematics	Bachelor's	Mathematical Sciences - B.S./M.D., D.M.D., D.D.S., O.D.	Accelerated
SL	Mathematics	Doctoral	Mathematical Sciences - Ph.D.	
SL	Mathematics	Master's	Mathematical and Computational Finance - M.S.	
EN	Mechanical & Industrial Engr	Bachelor's	Mechanical Engineering - B.S.	
EN	Mechanical & Industrial Engr	Master's	Mechanical Engineering - M.S.	
EN	Mechanical & Industrial Engr	Doctoral	Mechanical Engineering - Ph.D.	
EN	Mechanical & Industrial Engr	Master's	Occupational Safety and Health Engineering - M.S.	
SL	History	Bachelor's	Patent Law, Technology and Culture - B.A.	

College	Department	Degree Level	Discipline	Special Degree Options
SL	Chemistry & Environmental Sci.	Master's	Pharmaceutical Chemistry - M.S.	
EN	Chemical and Materials Engr	Master's	Pharmaceutical Engineering - M.S.	
EN	Mechanical & Industrial Engr	Master's	Pharmaceutical Systems Management - M.S.	
EN	Electrical & Computer Engr.	Master's	Power and Energy Systems - M.S.	
SL	History	Bachelor's	Pre-Law - B.A./J.D.	Accelerated
SL	Humanities	Master's	Professional and Technical Communication - M.S.	
SL	Humanities	Bachelor's	Science, Technology & Society - B.S./J.D.	Accelerated
SL	Humanities	Bachelor's	Science, Technology & Society - B.S./M.D., D.D.S., O.D.	Accelerated
CC	Informatics	Bachelor's	Science, Technology and Society/Business and Information Systems - B.S.	Double Major
SL	Humanities	Bachelor's	Science, Technology, & Society - B.S.	
CC	Computer Science	Master's	Software Engineering - M.S.	
EN	Electrical & Computer Engr.	Master's	Telecommunications - M.S.	
SL	Humanities	Bachelor's	Theatre Arts and Technology - B.A.	
EN	Civil & Environmental Engr	Master's	Transportation - M.S.	
EN	Civil & Environmental Engr	Doctoral	Transportation - Ph.D.	
AD	Architecture	Doctoral	Urban Systems - Ph.D.	
CC	Informatics	Bachelor's	Web & Information Systems - B.S.	

Special Program Options

BS/MS and Dual Degree Programs

These accelerated dual degree programs (https://www.njit.edu/graduatestudies/degree-programs/bs-ms/) permit undergraduates to earn credits toward a master's degree or a doctoral degree. Students in BS/MS normally take 6 credits of graduate course work in their senior year. Exceptional students with a cumulative GPA higher than 3.5 may take 9 credits of graduate course work in their senior year. These credits may be counted toward both a bachelor's degree and a following master's degree. **Students are encouraged to pursue graduate study immediately following the completion of the bachelor's degree. Students who may wish to start pursuing a graduate degree later should keep in mind that courses expire after seven (7) years. The graduate advisor will determine the graduate-level courses taken for the NJIT undergraduate degree that will also count toward the graduate degree.** After enrollment as a graduate student, those who wish to apply the 6 or 9 credits to the graduate degree program should contact the Office of Graduate Studies. Graduate study may be completed full or part-time.

Full-time undergraduate students become eligible to apply for the BS/MS program after they complete at least five courses in their major and have maintained a GPA of 3.0 or better. Students in the Albert Dorman Honors College are pre-approved for the BS/MS program at the time of admission to NJIT but will receive letters about activating their status in BS/MS if their GPA is still above 3.0 and have earned between 57 and 110 undergraduate credits. The activation letter will instruct Honors College students about contacting the academic department undergraduate advisor. All other students with a 3.0 or better GPA will have to submit an application to the Office of Graduate Studies no later than one year prior to graduation. The application will list the graduate courses to be taken in the senior year and requires the signatures of the undergraduate and graduate advisors. Applicants must satisfy all university requirements for admission to graduate programs (they must eventually submit an application to Admissions).

Exceptional students may seek to go into an NJIT doctoral program directly through the BS/PhD program and must have a record consistent with university criteria for doctoral study (3.5 GPA or better). GRE scores are required for doctoral admission.

Several other combinations of Bachelor’s and Master’s degrees exist or are under development. The number of dual-use credits for these combinations may exceed 6 credits in accordance with specific program requirements. Two examples are the B. Arch/MS and the BS/MBA programs which allow 12 dual-use credits. Information and applications for BS/MS, BS/PhD, and other accelerated dual degree programs can be obtained from the Office of Graduate Studies website under forms and printed materials.

MS-MS & MS-MBA Program Options

The MS-MS and MS-MBA dual degree program options allow students to pursue a second NJIT graduate degree upon completion of the first and to count two courses (6 credits) or four courses (12 credits), respectively, from the first degree toward the second. Most students

continue their studies for the second graduate degree as soon as they finish with the first. Students who may wish to start pursuing their second graduate degree later should keep in mind that courses expire after seven (7) years. The second program's academic advisor will determine the graduate-level courses taken for the first NJIT degree that will also count toward the second degree. The approval of the advisors of the two programs is required to pursue a dual degree program option. Upon receiving the signed approval form, the Office of Graduate Studies will direct the Registrar on transfer of the two dual-use courses to the second program. The MS/MS program option is not intended for students who have left the doctoral program without completion of the degree. Up to 6 credits may be transferred to the second Master's degree from outside NJIT. Thesis, project, pre-doctoral research, independent research and similar courses may not be used.

Several other Master's degree combinations (https://www.njit.edu/graduatestudies/degree-programs/ms-ms/) can allow more than 6 credits to count toward both degrees. In general, these apply to situations in which the first or the second degree programs requires considerably more than 30 credits. Examples are the Master of Architecture and the Master of Business Administration programs. The allowable dual counting of credits for the Master of Architecture in combination with other programs is described in the catalog sections on Architecture and Infrastructure Planning. Subject to specific course approval and the two year time limit for MS/MS as described above, up to 12 credits from a previously completed NJIT MS program in Computer Science, Information Systems, or Engineering Management may be applied toward completion of the 48 credit Master of Business Administration degree program. Subject to course approval, up to 18 credits may be used from a previously completed NJIT MS program in Management toward the completion of the 48 credit Master of Business Administration degree program.

The Collaborative Doctorate

The Collaborative Ph.D. program is designed for engineers, executives, scientists, military personnel, state and federal government employees, and educators who want to pursue a Ph.D. degree part-time while continuing full-time employment. The admission and academic requirements are the same as for NJIT's regular Ph.D. programs but the collaborative nature of the program allows participants to draw on the combined expertise and resources of the university and their employer. The dissertation research of students in the collaborative Ph.D. is expected to produce original contributions to science, engineering, technology or management and satisfy all quality criteria set by the dissertation committee. The student's main dissertation advisor is an NJIT faculty member while the research may meet the needs of the student and employer in advancing knowledge in the chosen discipline.

To apply to the collaborative Ph.D. program, candidates must have been employed in their specified field for at least a year. NJIT's standard criteria for admission will be applied but prior work-related research activity, publications, and honors will also be considered in evaluating prospective participants.

More information about the program is available at https://next.catalog.njit.edu/graduate/academic-policies-procedures/collaborative-doctorate/ (https://catalog.njit.edu/graduate/academic-policies-procedures/collaborative-doctorate/).

Graduate Certificates

NJIT's graduate certificates give students the opportunity to:

(a) improve their skills in their current occupation by developing expertise in advanced topics,
(b) acquire knowledge to pursue new careers, or
(c) explore emerging fields before committing to relevant master's degree programs that require more courses.

Many students pursue a graduate certificate for personal growth or part-time.

Each certificate program contains 4 graduate courses (equivalent to a total of 12 graduate credits) that are normally part of the curriculum for a 30-credit Master's degree program. After successful completion of a graduate certificate, a student may decide to continue studying at NJIT towards the corresponding Master's degree by taking advantage of rapid matriculated acceptance and eventual acquisition of two credentials (essentially for the price of the Master's degree).

Graduate Certificates are available in:

Full List of Graduate Certificates

Certificate Name	Industry	College	Dept	Advisor	Related MS
Applied Science **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/applied-science-cert/**) ***	Instructional Design, Science	CSLA (http://csla.njit.edu/)	HUM (http://humanities.njit.edu/)	Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)	APSC (https://www.njit.edu/graduatestudies/file/njit-ms-applied-science-teacherspdf/)

Applied Statistical Methods **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/applied-statistical-methods-cert/**)**	Applied Mathematics, Biostatistics	CSLA (http://csla.njit.edu/)	MATH (http://math.njit.edu/)	Ji Meng Loh (http://directory.njit.edu/PersDetails.aspx?persid=loh)	APST (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistics-ms/)
Big Data Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/big-data-essentials-cert/**)**	Computing, Analytics	YWCC (http://ccs.njit.edu/)	CS (http://cs.njit.edu/)	Chase Wu (http://directory.njit.edu/PersDetails.aspx?persid=chasewu)	DS (https://catalog.njit.edu/graduate/computing-sciences/computer-science/data-science-ms/)/CS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/ms/)
Biomedical Device Development **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/biomedical-device-development-cert/**)**	Biomedical	NCE (http://engineering.njit.edu/)	BMED (http://biomedical.njit.edu/)	Max Roman (http://directory.njit.edu/PersDetails.aspx?persid=mxr6074)	BMED (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/ms/)
Biostatistics Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/biostatistics-cert/**)**	Biostatistics	CSLA (http://csla.njit.edu/)	MATH (http://math.njit.edu/)	S. Subramanian (http://directory.njit.edu/PersDetails.aspx?persid=sundars)	BSTA (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/biostatistics-ms/)
Cell & Gene Therapy Sciences (formerly Biotechnology) **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/biotechnology-cert/**)**	Pharmaceutical Chemistry, Bioscience	CSLA (http://csla.njit.edu/)	CHES (http://chemistry.njit.edu/)	Kevin Belfield (http://directory.njit.edu/PersDetails.aspx?persid=belfield)	PHCH (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/pharmaceutical-chemistry-ms/)
Business and Information Systems Implementation **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/business-information-systems-cert/**) ***	Management, Information Systems	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Nisha Reyes (http://directory.njit.edu/PersDetails.aspx?persid=nreyes)	BIS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-ms/)/CBUS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/computing-business-ms/)/IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)

Clinical Trials: Design & Analysis **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/clinical-trials-design-analysis-cert/**)** New!	Data Science, Applied Statistics	CSLA (http://csla.njit.edu/)	MATH (http://math.njit.edu/)	Sunil Dhar (http://directory.njit.edu/PersDetails.aspx?persid=dhar)	APST (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistics-ms/)
Construction Management **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/construction-management-cert/**) ***	Civil Engineering	NCE (http://engineering.njit.edu/)	CEE (http://civil.njit.edu/)	Sylvana Brito (http://directory.njit.edu/PersDetails.aspx?persid=brito)	CE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/)/EM (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/)
Data Mining **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/data-mining-cert/**) ***	Computing, Databases	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Nisha Reyes (http://directory.njit.edu/PersDetails.aspx?persid=nreyes)	CS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/ms/)/IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)/BIS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-ms/)
Data Visualization **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/data-visualization-cert/**)** New!	Data Science, Visualization	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Aritra Dasgupta (http://directory.njit.edu/PersDetails.aspx?persid=dasg018)	IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)/PTC (https://catalog.njit.edu/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)
Digital Marketing Design Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/digital-marketing-design-cert/**) ***	Digital Media, Social Media	CSLA (http://csla.njit.edu/)	HUM (http://humanities.njit.edu/)	Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)	PTC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Environmental Engineering **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/environmental-engineering-cert/**)** New!	Civil Engineering, Environmental Engineering	NCE (http://nce.njit.edu/)	CEE (http://civil.njit.edu/)	Taha Marhaba (http://directory.njit.edu/PersDetails.aspx?persid=marhaba)	ENE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-ms/)/CE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/)
Environmental Science **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/environmental-science-cert/**)** New!	Environmental Science, Conservation	CSLA (http://csla.njit.edu/)	CHES (http://chemistry.njit.edu/)	Linda Cummings (http://directory.njit.edu/PersDetails.aspx?persid=lcumming)	EVSC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/)
Environmental Science and Engineering **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/environmental-science-and-engineering-cert/**)** New!	Environmental Science, Conservation	CSLA (http://csla.njit.edu/)	CHES (http://chemistry.njit.edu/)	Linda Cummings (http://directory.njit.edu/PersDetails.aspx?persid=lcumming)	EVSC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/)
Finance for Managers **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/finance-managers-cert/**)**	Management, Finance	MTSM (http://management.njit.edu/)	MGMT (https://management.njit.edu/)	Lilia Lozarito (http://directory.njit.edu/PersDetails.aspx?persid=lozarito)	MBA (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/)
Financial Technology **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/financial-technology-cert/**)** New!	Management, FinTech	MTSM (http://management.njit.edu/)	MGMT (https://management.njit.edu/)	Lilia Lozarito (http://directory.njit.edu/PersDetails.aspx?persid=lozarito)	MGMT (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/)
Hydrology and Water Resources Engineering **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/hydrology-water-resources-engineering-cert/**)** New!	Hydrology, Civil/Environmental Engineering	NCE (http://nce.njit.edu/)	CEE (http://civil.njit.edu/)	Taha Marhaba (http://directory.njit.edu/PersDetails.aspx?persid=marhaba)	ENE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-ms/)/CE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/)

Information Security **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/information-security-cert/**) ***	Computing, Network Security	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Nisha Reyes (http://directory.njit.edu/PersDetails.aspx?persid=nreyes)	CSP (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/cyber-security-privacy-ms/)/IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)/ITAS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/administration-security-ms/)
Instructional Design, Evaluation **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/instructional-design-evaluation-assessment-cert/**)** **and Assessment ***	Education, Digital Trainers	CSLA (http://csla.njit.edu/)	HUM (http://humanities.njit.edu/)	Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)	PTC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)
Intelligent Transportation Systems **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/intelligent-transportation-systems-cert/**)**	Transportation, Civil Engineer	NCE (http://engineering.njit.edu/)	CEE (http://civil.njit.edu/)	Joyoung Lee (http://directory.njit.edu/PersDetails.aspx?persid=jo02)	TRAN (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-ms/)
IT Administration **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/it-administration-cert/**) ***	Computing, Network Security	YWCC (https://ccs.njit.edu/)	IT (http://it.njit.edu/)	Michael Halper (http://directory.njit.edu/PersDetails.aspx?persid=halper)	ITAS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/administration-security-ms/)
Management Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/management-essentials-cert/**) ***	Management, Business	MTSM (http://management.njit.edu/)	MGMT (https://management.njit.edu/)	Cheickna Sylla (http://directory.njit.edu/PersDetails.aspx?persid=sylla)	MGMT (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/)/MBA (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/)

Management of Technology **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/management-technology-cert/**) ***	Management, Business	MTSM (http://management.njit.edu/)	MGMT (https://management.njit.edu/)	Cheickna Sylla (http://directory.njit.edu/PersDetails.aspx?persid=sylla)	MGMT (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/)/MBA (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/)
Network Security and Information **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/network-security-information-assurance-cert/**)** **Assurance ***	Computing, Network Security	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Nisha Reyes (http://directory.njit.edu/PersDetails.aspx?persid=nreyes)	IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)/CSP (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/cyber-security-privacy-ms/)/ITAS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/administration-security-ms/)
Neuroscience **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/neuroscience-cert/**)** New!	Neural Networks, Biology	CSLA (http://csla.njit.edu/)	BIOL (http://biology.njit.edu/)	Dirk Bucher (http://directory.njit.edu/PersDetails.aspx?persid=bucher)	BIOL (https://catalog.njit.edu/graduate/science-liberal-arts/biology/ms/)
Pharmaceutical Management **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/pharmaceutical-management-cert/**) ***	Management, Pharma, FDA	NCE (http://engineering.njit.edu/)	CME (http://chemicaleng.njit.edu/)	Edward Dreyzin (http://directory.njit.edu/PersDetails.aspx?persid=dreyzin)	PSM (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/pharmaceutical-systems-management-ms/)/PHEN (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-biological-pharmaceutical/pharmaceutical-ms/)
Pharmaceutical Manufacturing **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/pharmaceutical-manufacturing-cert/**)**	Drug Manufacturing, FDA	NCE (http://engineering.njit.edu/)	CME (http://chemicaleng.njit.edu/)	Edward Dreyzin (http://directory.njit.edu/PersDetails.aspx?persid=dreyzin)	PHEN (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-biological-pharmaceutical/pharmaceutical-ms/)

Pharmaceutical Technology **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/pharmaceutical-technology-cert/**)**	Drug Development, FDA	NCE (http://engineering.njit.edu/)	CME (http://chemicaleng.njit.edu/)	Edward Dreyzin (http://directory.njit.edu/PersDetails.aspx?persid=dreyzin)	PHEN (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-biological-pharmaceutical/pharmaceutical-ms/)
Polymers and Plastics **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/polymers-and-plastics-cert/**)** New!	Chemical / Materials / Polymers Engineering	NCE (http://engineering.njit.edu/)	CME (http://chemicaleng.njit.edu/)	Edward Dreyzin (http://directory.njit.edu/PersDetails.aspx?persid=dreyzin)	MTSE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-ms/)
Power Systems Engineering **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/power-systems-engineering-cert/**) ***	Power and Energy	NCE (http://engineering.njit.edu/)	ECE (http://ece.njit.edu/)	Mengchou Zhou (http://directory.njit.edu/PersDetails.aspx?persid=zhou)	EE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/electrical-ms/)/PES (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/power-energy-systems-ms/)
Project Management **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/project-management-cert/**) ***	Management, Engineering	NCE (http://engineering.njit.edu/)	MIE (http://mie.njit.edu/)	A. Bladikas (http://directory.njit.edu/PersDetails.aspx?persid=bladikas)	EM (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/)
Social Media Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/social-media-essentials-cert/**) ***	Digital Media, Social Media	CSLA (https://csla.njit.edu/)	HUM (http://humanities.njit.edu/)	Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)	PTC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)
Software Engineering, Analysis, **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/software-engineering-analysis-design-cert/**) and Design ***	Software Development	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Nisha Reyes (http://directory.njit.edu/PersDetails.aspx?persid=nreyes)	SE (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/software-engineering-ms/)/IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)

Supply Chain Engineering **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/supply-chain-engineering-cert/**)**	Industrial Engineering	NCE (http://engineering.njit.edu/)	MIE (http://mie.njit.edu/)	Sanchoy Das (http://directory.njit.edu/PersDetails.aspx?persid=das)	IE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/industrial-ms/)/EM (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/)/MNE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/manufacturing-systems-ms/)
Technical Communication Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/technical-communication-cert/**) ***	Writers, Editors, Digital Media	CSLA (http://csla.njit.edu/)	HUM (http://humanities.njit.edu/)	Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)	PTC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)
Transportation Studies **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/transportation-studies-cert/**) ***	Transportation Engineer	NCE (http://engineering.njit.edu/)	CEE (http://civil.njit.edu/)	I Jy Steven Chien (http://directory.njit.edu/PersDetails.aspx?persid=chien)	TRAN (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-ms/)/CE (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/)
User Experience Essentials **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/user-experience-essentials-cert/**) ***	Digital Designers, UX Design	CSLA (http://csla.njit.edu/)	HUM (http://humanities.njit.edu/)	Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)	PTC (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)
Web Systems Development **(**https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/web-systems-development-cert/**)**	Web Development	YWCC (http://ccs.njit.edu/)	IS (http://is.njit.edu/)	Nisha Reyes (http://directory.njit.edu/PersDetails.aspx?persid=nreyes)	IS (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)

Collaborative Doctorate

Collaborative Doctorate

The Collaborative Ph.D. program is designed for engineers, executives, scientists, military personnel, state and federal government employees, and educators who want to pursue a Ph.D. degree part-time while continuing full-time employment. The admission and academic requirements are the same as for NJIT's regular Ph.D. programs but the collaborative nature of the program allows participants to draw on the combined expertise and resources of the university and their employer. The dissertation research of students in the collaborative Ph.D. is expected to produce original contributions to science, engineering, technology or management and satisfy all quality criteria set by the dissertation committee. The student's main dissertation advisor is an NJIT faculty member while the research may meet the needs of the student and employer in advancing knowledge in the chosen discipline.

To apply to the collaborative Ph.D. program, candidates must have been employed in their specified field for at least a year. NJIT's standard criteria for admission will be applied but prior work-related research activity, publications, and honors will also be considered in evaluating prospective participants.

Requirements

Before applying to the collaborative Ph.D. program, the candidate will seek the employer's commitment in any of the following ways:

1. The candidate will be allowed to use the employer's facilities (e.g., laboratory equipment or computing/IT infrastructure) to carry out dissertation research (NJIT's Ph.D. program director or potential dissertation advisor must be contacted in advance to discuss the suitability of available resources). Should the student leave the employer, a revised study/research plan may be developed.
2. The employer may suggest an in-house researcher to serve on the student's Ph.D. dissertation committee. This researcher, who must have a terminal degree in a relevant discipline, must be an active researcher and may serve as the candidate's dissertation co-advisor; the main advisor will be an NJIT faculty member. Patent and copyright issues are to be resolved prior to the start of the dissertation research, and preferably after successful completion of the required coursework and qualifying exam. Employers who have a proprietary interest in the student's dissertation research, including patent, copyright and technology transfer rights, are expected to execute formal IP (Intellectual Property) agreements with NJIT prior to the start of the dissertation research.

The student's Ph.D. dissertation committee and the Office of Graduate Studies determine residency requirements. It is expected that the employer will allow the student to concentrate on dissertation research for at least one year.

For more information about the program or to discuss potential paths that can lead to the degree, contact the Vice Provost for Graduate Studies (ziavras@njit.edu).

Executive Program

Executive Master of Business Administration

Tailored to the demanding schedules of working professionals, the solution focused 18-month, 48-credit program is customized for career advancement without interruption of professional obligations. Built upon the hallmarks of Innovation, Immersion, and Integration, this practical and results-oriented option emphasizes the application of advanced management strategies to traditional business challenges. With the added bonus of Saturdays and on-line flexibility, the EMBA offers both breadth and depth of business experience in an accelerated mode of delivery. Students are assigned independent and group projects emphasizing the employment of innovative management strategies in traditional corporate settings. Further, the students represent diverse industries and job functions, providing an enriching experience and balanced perspective. The curriculum consists of 4 Thematic Areas: Leadership, Globalization, Creativity and Innovation, and Business and Government Relations.

EMBA candidates have the opportunity to participate in a 7-10 day international study tour. Meeting with business leaders in their work environments, students learn first-hand the opportunities and issues posed by today's volatile-yet-exciting international business climate. Recent tours have included Brazil, France, The Czech Republic, Russia, Estonia, Chile, Argentina, and China. Students have called the trips "invaluable." *[I gained] "critical insight….we would never have learned in any classroom or textbook."*

Professional Leverage

The program offers the additional benefit of PMP or Risk Management certification training. This new program feature represents an integration of the EMBA with industry recognized professional qualifications.

Admission Requirements

These criteria are standard admission guidelines; however, each candidate is evaluated based upon his/her individual profile.

Candidates must have an earned bachelor's degree (4 year US equivalent) and must take the GMAT (minimum score of 500); the GRE (with a comparable score) is also acceptable.

GMAT Waivers

- Candidates with an earned Master's or PhD from a US or Canada based "accredited" program
- Candidates with a minimum GPA of 2.8 from a US based research intensive University
- Candidates [without masters degrees], who have "significant" management experience, may appeal to the EMBA admission committee for a GMAT waiver; there is no waiver guarantee.

Online Learning

Online Learning

Online Learning offers numerous graduate degrees, select Graduate Certificates, and graduate courses in many disciplines including communication, computer science, information systems, information technology, humanities, management, and engineering management. Online Learning offerings can be viewed at http://www5.njit.edu/online (http://www5.njit.edu/online/).

Online Learning provides students the opportunity to earn college credit through enrollment in online electronic-based courses. These courses are virtual learning communities with instructor-led online classrooms that utilize various technologies such as Moodle (http://moodle.njit.edu) for presenting course material, online quizzes, asynchronous and synchronous communication. Online courses are flexible and rigorous educational experiences suited to motivated students.

The program's reach is worldwide. Course material can be accessed through the Internet via learning management systems utilizing multimedia presentations.

Online Learning furnishes a convenient alternative to graduate distance learners and students who have scheduling conflicts. For more information, contact the Office of Graduate Studies at 973-596-3462 or email online@njit.edu.

Course Codes

NJIT Courses

The courses listed here have been approved in accordance with the policies of NJIT. Department or university needs may necessitate changes in this list, and courses may be cancelled because of insufficient registration. A list of scheduled courses will be issued by the registrar before each semester begins. Information found in the Degree Programs section of this catalog serves as a guide for program planning in consultation with departmental or program advisors.

Alphabetical Code

ACCT	Accounting
ARCH	Architecture
BINF	Biomedical Informatics
BME	Biomedical Engineering
CE	Civil Engineering
CHE	Chemical Engineering
CHEM	Chemistry
CIS	Computer and Information Sciences
ECE	Electrical and Computer Engineering (formerly CoE, EE)
ECON	Economics
EM	Engineering Management
ENE	Environmental Engineering
EPS	Environmental Policy Studies
EVSC	Environmental Science
FIN	Financial Management
HIST	History
HRM	Human Resource Management
IE	Industrial Engineering
MATH	Mathematics

ME	Mechanical Engineering
MECH	Mechanics
MGMT	Management
MIP	Infrastructure Planning
MIS	Management Information Systems (formerly Information Systems Management)
MNE	Manufacturing Systems Engineering
MPH	Public Health
MRKT	Marketing Management
MTSE	Materials Science and Engineering
OPSE	Optical Science and Engineering
OSHE	Occupational Safety and Health Engineering
PHEN	Pharmaceutical Engineering
PHYS	Physics
TRAN	Transportation

Numerical Code

Numbers from 500 to 599 (500G to 599G for Architecture) indicate entry-level graduate courses normally offered for students who require additional background for admission to 600- or 700-level courses.

Numbers from 600 to 699 indicate regular-level graduate courses normally associated with master's-level study.

Numbers from 700 to 799 indicate advanced-level graduate courses normally associated with research and/or doctoral-level study.

Rutgers-Newark Courses

The current Rutgers-Newark Schedule of Classes (https://sis.rutgers.edu/soc/) can be viewed for cross-registration along with the **Rutgers catalog** when planning for cross-registration.

Student Rights and Responsibilities

Rights and Responsibilities

Code of Professional Conduct

New Jersey Institute of Technology requires students to conduct themselves with decorum and to adhere to standards of ethical and professional behavior. NJIT has adopted, and requires all students to comply with, a Code of Professional Conduct. The policies and procedures governing this code are contained in a separate publication, the Student Handbook, and are deemed incorporated into this catalog. The student handbook, maintained by the Dean of Students Office, is available online at: www.njit.edu/handbook/ (http://www.njit.edu/handbook/)

Identification Card

All students must carry an NJIT identification card while on campus. An ID card must be presented at the request of a university administrator, faculty member or public safety officer. Facilities, parking, building access, and services of the university require presentation of a valid university ID.

Students should obtain an ID card as soon as possible after registration is completed. Photographs for ID cards are taken throughout the semester in the Department of Public Safety, located in the parking facility. Dates and times to obtain an ID are posted at the Campus Center Information Desk. Proof of registration in the form of a tuition receipt or registrar's receipt is required to obtain an ID card. These receipts also will be accepted as NJIT identification until the ID card is issued. ID validation stickers are issued each semester and are available at the Department of Public Safety or the Campus Center Information Desk.

Lost or stolen IDs should be reported as soon as possible to the Department of Public Safety. A replacement for a lost card is obtained by paying a $25 charge at the Bursar's Office cashier's window in the Student Services Mall and presenting the receipt at the Department of Public Safety where the card will be re-issued.

NJIT cards are not transferable. Cards are not to be loaned to anyone for any reason. ID cards are the property of NJIT and must be returned upon request.

Family Educational Rights and Privacy Act

(Effective Fall 2014, this policy supersedes all previous policies)

The Family Educational Rights and Privacy Act (FERPA) affords eligible students certain rights with respect to their education records. (An “eligible student” under FERPA is a student who is 18 years of age or older or who attends a postsecondary institution.) These rights include:

1. The right to inspect and review the student's education records within 45 days after the day New Jersey Institute of Technology receives a request for access. A student should submit to the registrar a written request that identifies the record(s) the student wishes to inspect. The registrar will make arrangements for access and notify the student of the time and place where the records may be inspected. If the records are not maintained by the registrar, the registrar shall coordinate access to inspect those records.

2. The right to request the amendment of the student’s education records that the student believes is inaccurate, misleading, or otherwise in violation of the student’s privacy rights under FERPA.

A student who wishes to ask New Jersey Institute of Technology to amend a record should write the registrar, clearly identify the part of the record the student wants changed, and specify why it should be changed.

If New Jersey Institute of Technology decides not to amend the record as requested, New Jersey Institute of Technology will notify the student in writing of the decision and the student’s right to a hearing regarding the request for amendment. Additional information regarding the hearing procedures will be provided to the student when notified of the right to a hearing.

3 . The right to provide written consent before New Jersey Institute of Technology discloses personally identifiable information (PII) from the student's education records, except to the extent that FERPA authorizes disclosure without consent. See “Additional Disclosure Information” below.

4. The right to file a complaint with the U.S. Department of Education concerning alleged failures by the New Jersey Institute of Technology to comply with the requirements of FERPA. The name and address of the Office that administers FERPA is:

Family Policy Compliance Office

U.S. Department of Education

400 Maryland Avenue, SW

Washington, DC 20202

Disclosure of Directory Information

New Jersey Institute of Technology, at its discretion, may provide directory information, in accordance with the provisions of the law including a student's name, address, telephone listing, date and place of birth, major field of study, participation in officially recognized activities and sports, weight and height of members of athletic teams, dates of attendance, degrees and awards received, and the most recent previous educational agency or institution attended by the student.

Students may request to withhold disclosure of directory information. To ensure that a request is properly processed, it must be submitted on the official ‘Request to Prevent Disclosure of Directory Information Form’, which is available in the Office of the Registrar. Request for non-disclosure will be honored by New Jersey Institute of Technology for one academic year and must be filed again at the beginning of the next academic year. New Jersey Institute of Technology assumes that failure on the part of any student to specifically request on the official form preventing the disclosure of directory information indicates individual approval of disclosure.

Additional Disclosure Information

FERPA permits the disclosure of PII from students’ education records, without consent of the student, if the disclosure meets certain conditions found in §99.31 of the FERPA regulations. Except for disclosures to school officials, disclosures related to some judicial orders or lawfully issued subpoenas, disclosures of directory information, and disclosures to the student, §99.32 of FERPA regulations requires the institution to record the disclosure. Eligible students have a right to inspect and review the record of disclosures. A postsecondary institution may disclose PII from the education records without obtaining prior written consent of the student –

• To other school officials within New Jersey Institute of Technology whom New Jersey Institute of Technology has determined to have legitimate educational interests. A school official is a person employed by New Jersey Institute of Technology in an administrative, supervisory, academic, research, or support staff position (including law enforcement unit personnel and health staff); a person serving on the board of trustees; or a student serving on an official committee, such as a disciplinary or grievance committee. A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her professional responsibilities for New Jersey Institute of Technology. This includes contractors, consultants, volunteers, or other parties to whom the school has outsourced institutional services or functions, provided that the conditions listed in §99.31(a)(1)(i)(B)(1) - (a)(1)(i)(B)(2) are met. (§99.31(a)(1))

• To officials of another school where the student seeks or intends to enroll, or where the student is already enrolled if the disclosure is for purposes related to the student’s enrollment or transfer, subject to the requirements of §99.34. (§99.31(a)(2))

• To authorized representatives of the U. S. Comptroller General, the U. S. Attorney General, the U.S. Secretary of Education, or State and local educational authorities, such as a State postsecondary authority that is responsible for supervising New Jersey Institute of Technology State-supported education programs. Disclosures under this provision may be made, subject to the requirements of §99.35, in connection with an audit or evaluation of

Federal- or State-supported education programs, or for the enforcement of or compliance with Federal legal requirements that relate to those programs. These entities may make further disclosures of PII to outside entities that are designated by them as their authorized representatives to conduct any audit, evaluation, or enforcement or compliance activity on their behalf. (§§99.31(a)(3) and 99.35)

• In connection with financial aid for which the student has applied or for which the student has received, if the information is necessary to determine eligibility for the aid, determine the amount of the aid, determine the conditions of the aid, or enforce the terms and conditions of the aid. (§99.31(a)(4))

• To organizations conducting studies for, or on behalf of, the school, in order to: (a) develop, validate, or administer predictive tests; (b) administer student aid programs; or (c) improve instruction. (§99.31(a)(6))

• To accrediting organizations to carry out their accrediting functions. ((§99.31(a)(7))

• To parents of an eligible student if the student is a dependent for IRS tax purposes. (§99.31(a)(8))

• To comply with a judicial order or lawfully issued subpoena. (§99.31(a)(9))

• To appropriate officials in connection with a health or safety emergency, subject to §99.36. (§99.31(a)(10))

• Information the school has designated as “directory information” under §99.37. (§99.31(a)(11))

• To a victim of an alleged perpetrator of a crime of violence or a non-forcible sex offense, subject to the requirements of §99.39. The disclosure may only include the final results of the disciplinary proceeding with respect to that alleged crime or offense, regardless of the finding. (§99.31(a)(13))

• To the general public, the final results of a disciplinary proceeding, subject to the requirements of §99.39, if the school determines the student is an alleged perpetrator of a crime of violence or non-forcible sex offense and the student has committed a violation of the school’s rules or policies with respect to the allegation made against him or her. (§99.31(a)(14))

• To parents of a student regarding the student’s violation of any Federal, State, or local law, or of any rule or policy of the school, governing the use or possession of alcohol or a controlled substance if the school determines the student committed a disciplinary violation and the student is under the age of 21. (§99.31(a)(15))

Anti-Discrimination Policy

New Jersey Institute of Technology reaffirms its commitment to a policy of non-discrimination on the basis of race, sex, sexual orientation, age, religion, ethnic origin, handicap or veterans' status in its employment policies, educational programs and activities under university control.

Assuring a climate of equal opportunity is the direct responsibility of all levels of management. Administrative and supervisory personnel are required to comply with applicable government regulations and the affirmative action goals of the university. Among these are Executive Orders 11246 and 11375 (Affirmative action); the Civil Rights Act of 1964, as amended; Title IX of the Education Amendments of 1972 (Sex Discrimination); Section 504 of the Rehabilitation Act of 1973; Americans with Disabilities Act (Non-discrimination on the Basis of Handicap); The New Jersey Law Against Discrimination, Title 10, Chapter 5, 10:5-1 to 10:5-28, NJ Revised Statutes, as amended; and the New Jersey Governor's Code of Fair Practices, Executive Order No. 21 (1965), as amended and Executive Order No. 39 (1991), "Prohibition in State Government of Discrimination Based on Sexual Orientation."

Any reported act of discriminatory behavior will be investigated through the Office of the Dean of Student Services, the Office of Compliance and Training, or the Office of General Counsel and Employment Policy Relations.

Sexual Harassment Policy

It is the continuing objective of the university to offer a work and study environment to its employees and students that rewards career and educational goals based upon relevant factors such as ability and work performance. Sexual harassment of employees and students is unacceptable. It is a barrier to educational and professional development and contrary to law and university policy.

In accordance with the NJIT Sexual Harassment Policy and Procedures, persons found to have violated university policy will face investigation, managerial review and possible disciplinary action up to and including employment termination and or dismissal from the university (for students). For a full copy of the university's policy prohibiting sexual harassment, please contact the Office of General Counsel and/or the Office of Compliance and Training.

Copyright Ownership

NJIT believes its role as an educational institution is best served by disclosing to the public all academic research, projects, theses and dissertations developed by students during the course of their studies or employment at the university.

Projects, theses and dissertations created by students shall be governed by the following provisions as outlined in NJIT's copyright policy under "Ownership and Disposition of Copyrightable Materials":

A. Copyright ownership of projects, theses and dissertations generated by research that is performed in whole or in part by the student with financial support in the form of wages, salaries, stipend, or grant from funds administered by the University shall be determined in accordance with the terms of the support agreement, or in the absence of such terms, shall become the property of the University.

B. Copyright ownership of projects, theses and dissertations generated by research performed in whole or in part utilizing equipment or facilities provided to the University under conditions that impose copyright restriction shall be determined in accordance with such restrictions.

C. Copyright in projects, theses and dissertations not within the provisions of Categories A and B of this policy shall be the property of the author. However, the student must, as a condition of a degree award, grant royalty-free permission to the University to reproduce and publicly distribute copies of the project, thesis or dissertation.

Requests for permission to publish Category A and B should be addressed to the Office of Intellectual Property.

For further information, call the Office of Intellectual Property, (973) 596-5825.

Ownership of Intellectual Property

In accordance with university policy, NJIT retains all right, title and interest to any and all intellectual property (i.e., inventions, discoveries, creative works, trade secrets and know-how) developed by NJIT students during the course of their studies or employment at the university or while using university facilities.

To protect against premature disclosure of an invention and/or publication of anything that may be of a proprietary nature, students must immediately report their intent to do so to the **Office of Technology Development**. Students must neither publish nor discuss proprietary information with anyone other than the Office of Technology Development or members of the University's Intellectual Property Committee. When a project, thesis or dissertation covers material that is potentially proprietary, both the student and the advisor must report the existence of such material to the Office of Graduate Studies and the Office of Technology Development; so that the University may expedite its review of such material and determine whether or not it is proprietary and should be protected under the University's guidelines for protecting its Intellectual Property. If necessary, the Office of Graduate Studies and the Office of Technology Development will take steps to sequester patentable material in archival documents such as theses and dissertations. If the University applies for a patent, the student will sign an appropriate assignment agreement. All income derived from such intellectual property will be shared between NJIT and the student in accordance with the University's published policy (see http://www.njit.edu/policies/sites/policies/files/lcms/pdf/patentpolicy.pdf).

For further information, call the Office of Intellectual Property, (973) 596-5825.

Property Loss and Damage

NJIT is not responsible for loss of property by fire or theft in its buildings or grounds. NJIT is not responsible for property damaged as the result of vandalism in its buildings or grounds.

Drug Abuse Prevention Program

New Jersey Institute of Technology prohibits the use of illegal drugs on its premises. University policy concerning possession and consumption of alcoholic beverages on campus subscribes to strict enforcement of the laws of the State of New Jersey, the County of Essex and the City of Newark. In addition, the policy stipulates that any consumption must occur within a responsible social framework wherein beverages are not the focus of the event.

Students with drug and alcohol abuse problems should be aware that they can receive information, counseling and referral assistance from the Office of the Dean of Student Services, the Counseling Center, the Health Services Office, or the Stop-In Center. The professional staff of the Counseling Center can provide substance abuse counseling and assessment in some situations and will refer more serious problems to off-campus facilities and services.

In addition, the university, through the Division of Student Services, offers a series of educational programs focused on the areas of drug and alcohol information and substance abuse prevention.

Drug-Free Workplace Policy

Student employees are subject to university policies regarding employment. New Jersey Institute of Technology is committed to maintaining a drug-free workplace in compliance with applicable laws. The university is further committed both to rigorous enforcement of applicable laws and policies and to support for those trying to cope with drug-related problems. The unlawful possession, use, distribution, dispensation, sale, or manufacture of controlled substances is prohibited on university premises. Any NJIT employee determined to have violated this policy or engaged in drug-related problems that have an impact upon the workplace may be subject to disciplinary action up to and including termination. At the discretion of the university, any employee convicted of a drug offense involving the workplace shall be subject to employee discipline (up to and including termination) and/or required to satisfactorily complete a drug rehabilitation program as a condition of continued employment.

The illegal use of controlled substances can seriously injure the health of employees, adversely affect the performance of their responsibilities, and endanger the safety and well-being of fellow employees, students, and members of the general public. Therefore, the university urges employees engaged in the illegal use of controlled substances to seek professional advice and treatment. Anyone who is employed at NJIT who has a drug problem is encouraged to contact the Director of the Employee Assistance Program (EAP), who will assist in obtaining available treatment. Employees engaged in contracts with the U.S. Department of Defense are additionally subject to Department of Defense requirements and may be required to submit to tests for the illegal use of controlled substances.

As a condition of employment, an employee of NJIT will notify his/her supervisor if he or she is convicted of a criminal drug offense involving the workplace within five days of the conviction. In the event any such conviction involves an employee working on a federal contract or grant, the university will notify the granting or contracting federal agency within 10 days of receiving notice of a conviction. A copy of this statement shall be given to all employees.

This statement and its requirements are promulgated in accordance with the requirements of the Drug-Free Workplace Act of 1988 enacted by the United States Congress. The university will continue its efforts to maintain a drug-free environment by adhering to the above policy and by providing through the EAP and the offices of Human Resources, and Compliance and Training, ongoing drug awareness programs.

Instructional Delivery

5 Modes of Instructional Delivery at NJIT [1]

1) **Face-to-Face**: Delivery of instruction is structured around in-person classroom meeting times. Instruction is delivered in person and students are expected to attend class. (sometimes referred to as traditional classroom courses[2])

2) **Hybrid**: Delivery of instruction in which some traditional face-to-face contact hours are replaced with required synchronous or asynchronous online instruction (frequently through the learning management system). The amount of online activity is set by the instructor and varies by course. Students should refer to the course syllabi for the course meeting schedule, however no Hybrid course should be more than 50% online. (sometimes referred to as blended learning)

3) **Converged Learning**: Delivery of instruction is independent of place, merging the physical and virtual classrooms. There is an attendance expectation and students can choose to attend class face-to-face or using real-time synchronous video conferencing technology. Some instructors may require occasional proctored exams. (sometimes referred to as a synchronous distributed course).

4) **HyFlex**: Delivery of instruction is independent of time and place, allowing for students to choose to attend class in any of three modes:
- **Face-to-face** – the traditional classroom model;
- **Synchronous online** – same time, different place; utilizing video conferencing technologies;
- **Asynchronous online** – different time, different place; utilizing multimedia learning objects and lecture capture technologies. Students are expected to follow a week-by-week schedule as outlined in the syllabus.

Students can choose to change which option they use to attend courses weekly. Some instructors may require occasional proctored exams.

5) **Online**: Delivery of instruction in which all course activity can be ***completed online*** through the learning management system. There are no required face-to-face sessions but students are expected to follow a week-by-week schedule as outlined in the syllabus. Work is typically done in an asynchronous mode and students can complete the coursework without coming to campus. Note: some instructors may require occasional synchronous online meetings or proctored exams.[3] (sometimes referred to as eLearning)

1 Contact hours are independent of delivery method and defined in the course catalog.
2 Definitions are aligned with OLN’s definitions https://onlinelearningconsortium.org/updated-e-learning-definitions-2/
3 See http://www.njit.edu/online/current-students/faq/ for more information about proctored exams.

Admissions and Financial Support

If you're looking for an edge, start by enrolling in one of our undergraduate, graduate or continuing education programs and becoming an active participant in the NJIT experience.

Find out what sets NJIT apart (http://www.njit.edu/about/rankings-and-recognition/) from other schools and what's new on campus and in the classroom. As a public university, our tuition and fees -- combined with a generous financial assistance (http://www5.njit.edu/financialaid/) (undergraduate and graduate) program -- put the edge within your reach.

NJIT awards funding to a select number of qualified full time Ph.D. students in the form of teaching and research assistantships. It also provides fellowships to a limited number of Master's and PhD students. For more information: http://www5.njit.edu/graduatestudies/finaid.php

Admissions

Every application for admission is processed through the Office of University Admissions and is reviewed by the Graduate Admissions Committee. Candidates are notified of their admission status by mail. Admission decisions cannot be communicated by telephone, e-mail, fax, in-person, or to third parties. For admissions information contact:

Office of University Admissions
New Jersey Institute of Technology

University Heights
Newark, NJ 07102-1982
(973) 596-3300, fax (973) 596-3461, e-mail: admissions@njit.edu

For an online application for admission go to www.njit.edu/admissions/apply-online.php (http://www.njit.edu/apply-now/)

Test Requirements

Graduate Record Examinations (GRE)

The GRE (general test) is required of all applicants to doctoral programs, all applicants seeking financial support, and all applicants whose most recent degree was awarded from an institution outside of the United States.

Specific master's programs: applied physics, architecture, biology, infrastructure planning, materials science and full-time applicants to engineering programs require all applicants to submit official GRE scores.

The GRE can be used to fulfill test requirements for the master's programs in information systems and in public health. The GRE is highly recommended for all other programs.

For further information about taking the GRE, contact: Educational Testing Service, P.O. Box 6000, Princeton, NJ, 08541; phone (609) 771-7670, 8 a.m. to 8:45 p.m.; www.gre.org (http://www.gre.org)

Graduate Management Admission Test (GMAT)

The GMAT is required for all applicants for the MBA in Management of Technology and the MS in Management programs. Students with significant business experience who are seeking admission into the MS in Management program may apply for a GMAT waiver. For additional information, contact the graduate admissions office at (973) 596-6378. The GMAT also can be used to fulfill test requirements for the master's programs in information systems and in public health.

For further information about taking the GMAT, contact: Educational Testing Service, P.O. Box 592, Princeton, NJ, 08541; phone (609) 771-7330, 8 a.m. to 8:45 p.m.; or www.gmat.org (http://www.gmat.org)

Law School Admission Test (LSAT)

The LSAT can be used to fulfill test requirements for the master's program in public health.

For further information about taking the LSAT, contact: Law School Admission Council, (215) 968-1001 or www.lsac.org (http://www.lsac.org)

Medical College Admission Test (MCAT)

The MCAT can be used to fulfill test requirements for the master's programs in information systems and in public health.

For further information about taking the MCAT, contact: Association of American Medical Colleges, (202) 828-0600 or https://www.aamc.org/ (https://www.aamc.org/students/)students (https://www.aamc.org/students/)/ (https://www.aamc.org/students/) For registration materials, contact: MCAT Program Office, P.O. Box 4056, Iowa City, Iowa, 52243; or phone (319) 337-1357.

Test of English as a Foreign Language (TOEFL)

All international applicants must show a TOEFL score of at least 550 (paper-based); 213 (computer-based); 79 (internet-based).

For further information about taking the TOEFL, contact: TOEFL/TSE Services, P.O. Box 6151, Princeton, NJ 08541; phone (609) 771-7100 Monday--Friday, between 8 a.m. and 9:45 p.m. and Saturday, between 9 a.m. and 4:45 p.m. New York time, for recorded information or personal assistance; or see www.toefl.org (http://www.toefl.org).

International English Language System (IELTS)

International applicants may submit results from the IELTS exam in lieu of the TOEFL. The minimum score is 6.5 with no sub-score lower than 6.0.

For further information about taking the IELTS, contact IELTS; www.ielts.org (http://www.ielts.org).

Master's Degree Programs

Master's degree programs provide advanced education needed by professionals in an era of rapidly expanding technology and normally require more specialization in the academic discipline of the student's bachelor's degree.

To be considered for a master's program at NJIT, you must have completed a four-year undergraduate program accredited in the United States, or its equivalent, and demonstrate strong academic achievement in an appropriate discipline

All applicants should submit supplementary evidence of their potential for successful graduate work. Letters of recommendation, GRE or GMAT scores, a publications record, prior research experience, a record of exceptional career development, a statement of the applicant's objectives, interests and professional experience are examples of appropriate supplementary evidence.

Bridge Program

Students who seek a master's degree in an academic discipline different from that of the bachelor's degree may be admitted to a master's degree program but may be required to complete appropriate undergraduate and/or graduate prerequisites in addition to the normal graduate degree requirements of the program. The program of courses will be individually designed in consultation with their graduate advisor. Bridge courses must be completed before 9 credits of graduate degree courses are earned. Bridge courses are not counted as degree credits but do count in graduate GPA calculations if the course is numbered 500 (500G for Architecture) or higher.

Admissions Procedures for Master's Study

Students can access and submit the graduate application online at www.njit.edu/admissions/apply-online.php (http://www.njit.edu/apply-now/). A non-refundable application fee is required. Applications may be deferred for one semester for a delay in admission without incurring another fee. Official transcripts from all colleges and universities previously attended are required. To be accepted as official, transcripts must be sent directly to the Office of University Admissions by the institutions concerned. Applications for fall (September) admission must be received by June 1; for spring (January) admission by November 1. Applications for financial support for fall (September) must be received by December 15. Applications for financial support for spring (January) must be received by October 15. Supporting documents must also reach the Office of University Admissions by the above dates. Incomplete applications or applications received after these dates will normally be processed for the following semester.

Program Transfers

Students who wish to transfer from one master's degree program at NJIT to another at NJIT must complete the Change of Program Form and submit to the Office of Graduate Studies. Courses taken in one program are not necessarily transferable to another, nor may credits be applied to more than one degree, except as provided by the M.S./M.S. program. Students admitted to one degree program are normally required to be in the original program for one full year before admission and enrollment in another degree program.

Joint Master's Degrees with Other Universities

The university cooperates with Rutgers-Newark and with Rutgers Biomedical and Health Sciences in unique offerings of joint master's programs. Specific information about application and admission requirements for each is provided in the degree program descriptions located in the Degree Program section of this catalog. Programs that lead to joint master's degrees are applied physics, biology, computational biology, environmental science, and history with Rutgers-Newark and public health with Rutgers-Newark and RBHS. There is also a dual degree program in which a student may simultaneously earn a masters degree in Infrastructure Planning from NJIT and in City and Regional Planning from Rutgers-New Brunswick.

Doctoral Programs

New Jersey Institute of Technology offers doctoral programs to fill society's need for creative research scientists and engineers.

Admissions Requirements for Doctoral Study

If you are applying for admission to one of NJIT's doctoral degree programs, you are required to have an appropriate academic background as described by the individual degree programs and evidence of a high level of achievement, including GPA, in your prior studies.

GRE scores are required for admission to all doctoral programs.

An applicant who wishes to pursue a doctoral degree in a field different from that of previous study, and who is otherwise qualified, may establish eligibility by satisfactorily completing a program of study recommended by the department in which they seek admission.

Applicants who wish to complete a master's degree while pursuing a doctorate must apply for admission to the master's program. This requires the approval of the doctoral program and dean of graduate studies, and where permitted, generally occurs only at or near the completion of the doctoral program.

Mid-career scientists and engineers interested in part-time study may wish to consider the collaborative doctorate option described in the Graduate Studies section of this catalog.

Admissions Procedures for Doctoral Study

Admissions procedures are the same as for a master's degree. In addition, three letters of recommendation are required from individuals who can best judge the applicant's ability to pursue independent research and complete a doctoral program.

Joint Doctoral Degrees with Other Universities

NJIT cooperates with other universities in Newark in operating and developing doctoral programs of mutual interest.

The university participates in unique offerings of joint doctoral programs with Rutgers-Newark and RBHS. Students may apply and be admitted through either university. Programs that lead to joint degrees are applied physics, biology, environmental science and mathematical sciences with Rutgers-Newark, biomedical engineering with RBHS and urban systems with both Rutgers-Newark and RBHS.

NJIT faculty participate in the doctoral program in management offered by Rutgers-Newark. NJIT faculty supervise Rutgers doctoral students in this program. Admissions to the doctoral program in management is handled by Rutgers-Newark.

Admission Classifications

Degree (Matriculated Students)

Regular Admission

Applicants who meet NJIT standards and have an appropriate undergraduate academic background for the degree program to which they are seeking admission will be offered regular admission as degree-seeking (matriculated) students.

Conditional Admission

NJIT expects applicants to have a superior academic record, but recognizes that interest, creativity, maturity, and motivation are also important. Conditional admission to the university may be granted to applicants who do not have the appropriate academic background required for a particular degree program, but who have an academic record that meets NJIT's scholastic standards.

Once granted conditional admission, students must complete conditional or bridge courses specified by the university within their first two semesters. Such courses may be at either the undergraduate or graduate level and are NOT counted as degree credits although all courses numbered 500 (500G for Architecture) or higher are calculated in the cumulative GPA. Students must attain grades specified by the university and are not permitted to take more than 9 credits that count as graduate degree credits at NJIT before meeting the terms of conditional admission. Failure to meet these conditions may result in dismissal from the university.

Contingent Admission

Students who apply for admission to graduate programs before completing their bachelor's degree, and whose records demonstrate superior academic achievement, may be offered admission to NJIT contingent on their showing proof of receiving a bachelor's degree appropriate for the degree program for which they are seeking admission. Such students must show proof of graduation before being permitted to enroll in a graduate program.

Change of Program

Students are admitted to one graduate degree program and not to the university as a whole. Students who wish to change major on arrival at NJIT must file an application for the new program and must generally remain in the original program for one full year before the application is approved. There is no guarantee or requirement that the new application will be successful. Those on support are liable to loss of support from the original department and cancellation of a current award.

Change of Level

Students who wish to change current degree level must file an application for admission to the new degree level. There is no requirement or guarantee that the application will be successful. Students who wish to drop down to a master's program from a doctoral program should be aware of the impact of this action on current and future financial support. Students who wish to raise their level from a master's to a doctoral program should be aware of any impact on incomplete master's theses or projects.

Non-Degree (Non-Matriculated Students)

Students who wish to take graduate courses without seeking a degree (non-matriculated status) should contact the Office of University Admissions for a Non-Degree Application Form.

Non-matriculated students may be permitted to take a maximum of 9 graduate-level credits accumulated over three registration periods, except students seeking a graduate certificate. These students may take a maximum of 12 graduate-level credits accumulated over four registration periods. Students wishing to take credits beyond these limits must apply and be accepted to a degree program as a matriculated student.

Academically qualified students who do not desire to enter degree programs may enroll in certain individual graduate courses. Such students must present transcripts of previous academic work or other appropriate evidence at each registration in order to indicate adequate preparation for the course work involved. If approved by the Office of University Admissions, registration will be permitted if space is available. Permission to enroll as a non-matriculated student does not imply eventual admission to a degree program.

Graduate Certificate Programs

NJIT offers designated courses in concentrated areas for students wishing to obtain a graduate certificate in specific areas. These require completion of 12 NJIT credits at the graduate level. Students in these programs are generally non-matriculated students for the duration of the certificate program. Graduate certificate programs may also be completed during a matriculated graduate program by making use of degree credits. Students in a matriculated degree program are not permitted to receive a certificate until completion of the degree program. Only one certificate can be earned within the credits applied toward a master's degree.

Students Matriculated at Other Universities

Graduate degree students at other colleges or universities may take courses for credit at NJIT for transfer back to their home institution. In addition to satisfying the course prerequisites, students must furnish a letter of approval from an appropriate administrative officer of their home institution.

NJIT Undergraduates

NJIT undergraduates may register for graduate courses, 500- or 600-level, with written approval from both their undergraduate advisor and from the graduate advisor in the department in which the course is taught. NJIT students in the BS/MS program are required to take 6 graduate-level credits while undergraduates to satisfy BS/MS program requirements.

Rejected Applicants

Students whose application for admission to a degree program is unsuccessful are not permitted to register as non-matriculated students.

International Students

International students on F-1 and J-1 visas are not permitted to register as non-matriculated students. Students on other visas should consult the Office of University Admissions regarding non-matriculated status.

Auditors

Students who wish to attend courses for which they are qualified, but who do not wish to be graded in the course, may be permitted to enroll as auditors. Registration will be approved only after a review of credentials by the Office of University Admissions and only if space is available. A notation signifying that the course was audited will be made on the student's record, but no credit will be granted for the course. Students who wish to audit a course must state their intention at the time of registration. A change to, or from, auditor status is not permitted once a semester has begun. Students who audit a course are required to pay full tuition and fees. There is no tuition remission allowable for audited courses. Audited courses cannot be counted in determining full-time status.

Transfer Students

Students enrolled in graduate programs at other institutions may apply for transfer to NJIT by completing the normal admission procedure. Transfer students may apply for credit for courses taken at other U.S. educational institutions by following procedures outlined in "Transfer of Credits from Outside NJIT" in the Academic Policies and Procedures section of this catalog. In addition, international students wishing to transfer from other educational institutions in the United States must:

- Demonstrate a cumulative GPA of at least 3.0 in graduate courses taken at other U.S. educational institutions;
- Complete the required immigration procedures for transfer; and
- Be eligible for admission to the NJIT program of their choice.

To transfer to NJIT from another institution in the U.S., international students must already have been placed into SEVIS, The Student and Exchange Visitor Information System. NJIT will ask the "leaving institution" to verify the student's current standing in F-1 or J-1 status under immigration regulations. All financial and academic requirements must be completed before admission will be granted and the I-20 or DS-2019 issued.

International Students and TOEFL

New Jersey Institute of Technology welcomes applications from international students with records of superior academic achievement. In addition to the procedures stated below, international students are required to provide evidence of English language proficiency by submitting either the Test of English as a Foreign Language (TOEFL) or the International English Language System (IELTS) scores

For further information about taking the TOEFL, contact: TOEFL/TSE Services, P.O. Box 6151, Princeton, NJ 08541; (609) 771-7100 Monday-Friday, between 8 a.m. and 8:00 p.m. New York time, for recorded information or personal assistance; or see www.toefl.org (http://www.toefl.org).

For further information about taking the IELTS, contact IELTS; www.ielts.org (http://www.ielts.org).

Students with TOEFL scores of 550 (Paper-based); 213 (Computer-based); 79 (Internet-based); 6.5 (IELTS) or better are not required to take an ESL course but are encouraged to improve their English-language skills by doing so voluntarily.

All ESL courses are graded on an S/U (Satisfactory/Unsatisfactory) basis. The course credits count towards the 9 credits required for full-time status; however, the credits do not count toward degree credits.

International Students Who Seek Financial Support

Those seeking financial support from NJIT at the time of admission will be required to achieve a TOEFL score of at least 550 (Paper-based); 213 (Computer-based); 79 (Internet-based). Students who may be offered Teaching Assistant or similar positions are required to be tested for spoken English proficiency in advance of classroom or laboratory placement. The test is offered at NJIT after admission. New international students offered

TA or similar awards must also participate in the teaching assistant training program offered by ESL staff in advance of the first semester (usually in August.) All new TAs must register for ENG 599 in their first TA assigned semester.

International Student Financial Statement

In accordance with Department of Homeland Security, Bureau of Citizenship and Immigration Services requirements, international students must also submit to the Office of University Admissions an International Student Financial Statement to demonstrate financial resources sufficient to meet the academic and living costs of their anticipated stay at the university. International students should note that they will be required to pay non-resident tuition rates. Immigration papers (e.g., I-20, DS-2019) will NOT be issued until the International Student Financial Statement is on file with the Office of University Admissions.

Academic Credential Equivalents for International Students

Undergraduate degrees must be equivalent to the typical four-year program in the United States. NJIT is working with a number of countries and universities to provide a transition from two- and three-year degree programs to baccalaureate and later graduate study. To be eligible for admission to graduate study at NJIT, international students must have the following minimum academic qualifications.

Argentina	Licenciatura
Bahamas	Honors bachelor's degree
Barbados	Honors bachelor's degree
Bolivia	Licenciatura
Brazil	Bacharel or Licenciado
Canada	Honors bachelor's degree or equivalent
Chile	Bachillarato, Licenciatura or Titulo of at least four-year duration
People's Republic of China	Bachelor's degree
Colombia	Licenciatura or Titulo
Dominican Republic	Licenciatura of at least four-year duration
Ecuador	Licenciatura or Titulo
Egypt	Bachelor's degree
El Salvador	Licenciatura
France	Maitrise or equivalent
Germany	Ptychion
Guatemala	Licenciatura
Haiti	Diplome d"EtudesSuperieures or Licence of at least four-year duration
Honduras	Licenciatura of at least four-year duration
Hong Kong	Honors bachelor's degree
India	Bachelor's degree (first class) in Engineering or Architecture, master's degree in other
Indonesia	Sarjana or Insinyur
Iraq	Bachelor's degree
Israel	Bachelor's degree
Italy	Laurea
Jamaica	Honors bachelor's degree
Japan	Bachelor's degree
Jordan	Bachelor's degree
Korea	Bachelor's degree (Taehak Taehakkyo)
Kuwait	Bachelor's degree
Lebanon	Bachelor's degree, Licence of at least four-year duration, or Maitrise
Libya	Bachelor's degree
Malaysia	Bachelor's degree
Mexico	Licenciatura of at least four-year duration
Morocco	Licence or Ingenieur d'Etat
Netherlands	Doctorandus, Ingenieur or Meester
Nicaragua	Licenciatura
Nigeria	Honors bachelor's degree
Norway	Cand. Mag

Pakistan	Bachelor's degree in engineering or other four-year bachelor's degree or master's degree
Panama	Licenciatura
Paraguay	Licenciatura of at least four-year duration
Peru	Bachillerato, Licenciatura or Professor from four-year university program
Philippines	Bachelor's degree
Saudi Arabia	Bachelor's degree
Singapore	Honors bachelor's degree
Sweden	Filsofie Kandidatexamen or Ekonoexamen
Switzerland	Licence or Diplom of at least a four-year duration
Syria	Lisentiate or bachelor's degree
Rep. of China	Bachelor's degree
Thailand	Bachelor's degree
Trinidad and Tobago	Honors bachelor's degree
Turkey	Lisans or Bachelor's degree
United Kingdom	Honors bachelor's degree
Uruguay	Licenciatura of at least four-year duration
Venezuela	Licenciatura or equivalent

Students from countries whose universities do not provide transcripts, or who experience exceptional difficulty in obtaining transcripts, should contact the Office of University Admissions for special instructions. Students whose credentials cannot be evaluated by the Graduate Admissions Committee will be required to submit a Credential Evaluation Report from an approved agency. For further information, contact World Education Service, Inc., Old Chelsea Station, P.O. Box 745, New York, NY 10113-0745, (212) 966-6311; e-mail: info@wes.org

Financial Support

Financial Support and Graduate Awards

Various financial support and graduate award options are available to NJIT graduate students. Financial support comes from either NJIT internal funds or from external sources. Information on need-based support is detailed on **Student Financial Aid Services** website. Eligibility and selection criteria are summarized in the following table for both need-based and merit-based support. Funds for these are not guaranteed.

Type of Support	Contact	Who is Eligible
Federal Loans	Financial Aid 973-596-3479	US citizens, permanent residents; students enrolled at least half time, based on financial need; must file the Free Application for Federal Student Aid.
Private Loans	Financial Aid 973-596-3479	US citizens, permanent and non-resident students enrolled at 3 credits; need is not a factor and filing a Free Application for Federal Student Aid (FAFSA) is not a requirement.
Industry Co-op	Career Development Services 973-596-3100	Full-time students, based on position availability; master's students; doctoral students only by exception with approval by the associate provost of graduate studies
Work-study	Financial Aid 973-596-3479	US citizens, permanent residents, international students, full-time and part-time students, based on position availability.
Scholarships, Fellowships, Grants	Graduate Studies 973-596-3462	Based on funding source, full-time students, often supporting under-represented groups.
Assistantships	Graduate Studies 973-596-3462	Full-time, based on academic merit or priorities and on funds available.

NJIT Awards

Close to 400 teaching, research and graduate assistantships, based on academic merit, are awarded to qualified full-time students.

Prospective students can apply for financial support by using the Application for Admission to Graduate Study. Prospective students seeking financial support are urged to apply no later than December 15th for the fall semester of the following academic year and October 15th for the spring semester of the current academic year.

Prospective students seeking financial support should indicate their interest on the admissions application form. Continuing students seeking need-based support should contact the Student Financial Aid Services. Continuing students seeking merit-based financial support should contact the Office of Graduate Studies. GRE or GMAT scores are required of all applicants to doctoral programs, all applicants seeking financial support, and all applicants whose most recent degree was awarded from an institution outside of the United States. Some specific master's programs require them as well.Check the Admissions web site for updated information.

Competition for financial support is strong and only successful applicants are notified. Teaching, research, and graduate assistantship offers may include full or partial tuition, a stipend or both. Additional funds for the summer may be awarded.

Assistantships

Each year there are more than 400 teaching and research assistantships in academic and research departments, which are funded internally or externally. Teaching assistants conduct recitation, grading, discussion, laboratory, or provide other type of course support under the supervision of permanent faculty. These duties are considered part-time work equivalent to twenty hours per week. Research assistants conduct research under the supervision of NJIT faculty. Non-academic departments also sometimes employ students as graduate assistants. Duties range from academic support to day-to-day operation of administrative offices.

Provost Fellows

A limited number of fellowships with very competitive stipends and full tuition and fee support are offered to outstanding doctoral students.

Grader

A grader is appointed for part-time service and grades course work under the direction and supervision of a faculty member. Graders are normally hired on an hourly basis. Compensation is based on hourly rates established for this position.

Special Awards

Special awards for service may be established each year. Students should contact the Office of Graduate Studies for further information.

Non-Service Fellowships or Scholarships

The Office of Graduate Studies may be contacted for the availability of private, state, federal or foundation awards that do not require service to NJIT.

Unemployed or Displaced Workers

Students receiving tuition support because of an unemployed or displaced worker's program are alerted to potential loss of this form of support because of any salary or stipend that may be received for any form of on-campus or off-campus employment.

Stipend Support Levels for Teaching Assistants

These awards are available to doctoral students and normally provide full support.

Teaching Assistant (not supported by grants):

Doctoral students	$24,000	9 months at $2,666/month

Stipend support levels are re-evaluated each year and the levels reported above are minimum values for 20 hours per week of service for 9 months over the fall and spring semesters.

Research Assistants (on external funds from grants minimum award level)

Doctoral students	$26,000	12 months

Partial awards are possible from grants. Award periods are scheduled for two consecutive 4 and ½ month periods for 9 month awards and any following summer periods

Maximum Annual Support

While NJIT does allow multiple sources of support for individual students, there is an annual limit established each year for the maximum amount of support that an individual student may receive from all sources. The limit is established at a reasonably high and competitive level in comparison to reported maxima provided by a number of federal support programs. Students who are receiving support from outside NJIT must report this to their graduate program advisor and to the Graduate Studies Office to assure their not exceeding NJIT limits. Total support that would be in excess of the NJIT limit may require an adjustment in the support provided by NJIT sources. Excess support can also negatively impact need-based support arrangements.

Summer Support

Depending on availability of funds, students may be eligible for stipends and tuition support for June, July and August. NJIT has two summer award periods, the first covering late May and June, the second covering July and most of August. The split of summer award periods is based on the combination of the semester-based academic calendar used at NJIT and the changeover to a new fiscal year on July 1. Interested students should consult their faculty advisors in March or April.

International Students

Private loans are available through Student Financial Aid Services. These loans require a cosigner who is a U.S. citizen or permanent resident alien.To learn more, go to: http://www.njit.edu/financialaid/typesofaid/educationloans/privateloans.php

International students may not receive NJIT support or be employed on-campus during periods of practical training. International students must be in status with the United States Citizenship and Immigration Services (USCIS). International students are eligible only for merit-based NJIT financial support and not for need-based state or federal finds.

USCIS regulations require that international students attest to having funds sufficient to cover the expense of the entire course of study before they will grant a visa. Students are expected to demonstrate the availability of funds for the duration of studies at NJIT as a requirement for admission to the university.

Government-Funded Support for Graduate Studies

NSF and NRC Programs

The National Science Foundation (NSF) and the National Research Council (NRC) support doctoral stipends and tuition in a very competitive process. Application deadlines for these programs are one year in advance of anticipated study, usually in early fall. Visit the Office of Graduate Studies (http://www5.njit.edu/graduatestudies/) website for information on these and other federal programs. NJIT participates in regional consortia for the Bridges to the Doctorate and Alliance for Graduate Education for the Professorate supported by the NSF.

GEM

The National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. supports graduate students within an industry and academe-based consortium. Contact the Office of Graduate Studies (http://www5.njit.edu/graduatestudies/) for information on this and other industry programs.

Federal Direct and Work-Study Programs

US citizens and Permanent Residents are eligible to apply for federal loans from the William D. Ford Federal Direct Loan Program and for Federal Work-Study (FWS). To obtain a Federal Direct Loan, eligible applicants must file the Free Application for Federal Student Aid (FAFSA) with the Federal Student Aid Programs Processing Center. To be considered for FWS, eligible students must file the FAFSA no later than the February 15th priority deadline. The amount of graduate tuition remission a student receives is considered when determining eligibility for loans and work-study. Before loans are disbursed, students must sign a promissory note and complete entrance counseling at studentloans.gov (https://studentloans.gov/myDirectLoan/index.action/). The FAFSA is available at www.fafsa.gov (https://fafsa.ed.gov/).

For further information, contact **Student Financial Aid Services** at finaid@njit.edu or (973) 596-3479.

Terms and Conditions of Awards

Award Selection

All NJIT awards are merit-based and are offered only to academically superior students who meet all selection requirements. Many things are considered in evaluating applications and nominations for NJIT awards. Among these are GPAs, GRE and GMAT scores, undergraduate and graduate academic performance, educational preparation, TOEFL scores for international students, skill and talent required for available positions, institutional priorities, availability of funds, special skills, and prior experience.

Students must take the GRE or GMAT and arrange to have official score reports to be sent to NJIT before they may become eligible to receive awards. Although there is no minimum eligibility score for the GRE or GMAT, NJIT may establish them for certain awards.

Graduate students who have not already received awards or had not been offered an award on admission must attain a minimum GPA of 3.5 for first-time support from internal funds and 3.0 for first-time support from external funds. Any graduate or undergraduate course taken by a student in graduate studies at NJIT is counted in the GPA (as calculated by Student Financial Aid Services) for evaluating selection criteria, including courses that were repeated or excluded. GPAs are checked at the beginning of each support period to verify that awards are warranted. GPAs only establish eligibility and neither guarantee nor entitle students to receive financial support.

The Office of Graduate Studies evaluates criteria for support from internal funds each year. The criteria reflect both average grade point performance levels and availability of funds. A student who has received support from NJIT funds for one degree cannot receive NJIT support for another degree of the same or lower level or type. Criteria and full details of terms and conditions of awards are available from the Office of Graduate Studies.

Need-based support programs administered by Student Financial Aid Services have different criteria for selection; contact Student Financial Aid Services for further information. Funds distributed for hourly employment are not considered awards.

Service-Based Awards

A service-based award is one in which the student is required to perform a service in return for a stipend. The following awards are service-based: graduate assistants, teaching assistants, research assistants, provost fellows, teaching fellows, graders, and others as noted.

Terms and Conditions

By accepting an award, students agree to comply with the following terms and conditions unless exceptions are indicated in their award offer letter:

- Students are required to work, up to a maximum of 20 hours per week, for Fall and Spring semester awards. Students are therefore required to work during semester breaks, either for their supervisor or, with the consent of the supervisor, on their own research.
- Students not receiving the maximum award for their award category and degree status are required to work a prorated number of hours (less than 20) based on a comparison of their award to the stipend level allowed for that award. A maximum of 35 hours per week, with appropriate increase in support level, may be permitted for service during the two summer award periods.
- Full-time registration in one of NJIT's graduate degree programs must be maintained at all times throughout the period of an award. Full-time status is accorded to those who complete at least 9 credits per semester, or to those who are certified by the Office of Graduate Studies or designated as full-time students. Students should review "Refunds for Withdrawal" and "Enrollment Status" in the Tuition and Fees section and the Academic Policies and Procedures section respectively in this catalog to be assured that they are following full-time certification requirements.
- Students who initially register for a full-time load but withdraw during a semester and thus become part-time cannot receive tuition remission for that semester and may have their tuition award terminated and stipend award curtailed.
- No other work for compensation, whether on- or off-campus, may be undertaken during the period of the award unless approved by the Associate Provost for Graduate Studies. Students who do not comply with this requirement may be prohibited from receiving future support and have their current award terminated.
- Unsatisfactory performance, inadequate academic progress, or violation of any of the terms and conditions shall constitute grounds for the immediate cancellation of an award.
- Award offers must be accepted in writing, on an appropriate form, and must be received by the date indicated in the award offer.
- Students who resign, or are dismissed from an appointment during a semester, must repay any tuition remitted for that semester.
- Students must report to their supervisor no later than the first day of each semester. Students who fail to do so will be deemed to have resigned and will have their award cancelled.
- Appointments are made for the period specified in the award offer. Neither renewal nor summer support can be guaranteed.
- Support based on external grant, contract, scholarship or fellowship awards are subject to the limitations established by the external agency.
- Students may not receive an award from NJIT funds to pursue a second master's degree or second doctoral degree when the first degree has been earned at NJIT.
- Students who change to a master's degree program from a doctoral program will have the current award cancelled and no future awards will be permitted. Students who register in courses inappropriate to their program of record or unapproved by their advisor will have the award immediately terminated.

Tuition Remission Awards

Tuition support has no service condition associated with it. Students accepting this support must not leave the program for which the support is offered without the approval of the support sponsor and the Associate Provost for Graduate Studies. Approval will be granted only for sound academic or other compelling reasons. Departure to accept employment is not considered a valid reason. All tuition support provided will be re-billed to the student if this condition is violated.

Cancellation of Tuition Remission

NJIT reserves the right to cancel tuition remission awards when students do not meet requirements or violate the conditions of an award. NJIT also reserves the right to cancel tuition remission for ineligible courses or courses for which the grades of F, U, W, or I are received. Audited courses, courses outside the approved courses for the program, and excess courses not needed for program completion are ineligible for tuition remission. If tuition remission is cancelled, students are re-billed accordingly and are responsible for payment in full.

Sick Leave

Students receiving awards are entitled to a total of three paid days of sick leave during the academic year. Additional days of sick leave may result in the cancellation of an award or a reduction in a stipend.

Unsatisfactory Performance for Service Awards

A student's performance is considered unsatisfactory if it does not meet the criteria set by the award supervisor.

Criteria for Maintaining Award

Students must earn at least a 3.0 GPA each semester, as well as maintain a cumulative GPA of 3.0 to keep receiving their awards. A 3.0 GPA will also maintain awards that initially required higher GPAs to receive them. Any graduate or undergraduate course taken by a graduate student is counted in the GPA for evaluating maintenance of awards and even includes courses that were repeated or excluded. Except for the specified period of the award offer, these criteria neither guarantee nor entitle students to receive continued financial support. Departments may set higher but reasonable standards (typically 3.5 or above cumulative GPA) for continuation of awards.

Effect of Incomplete Grades and Grade Changes

Students whose transcripts show incomplete (I) grades in the semester before being selected or becoming eligible for an award must resolve them within the four weeks after grades are posted. This also applies to changes in grades that would affect eligibility.

Extension of the deadline to beyond the fourth week of the semester will be considered if the student and the instructor provide written justification. Otherwise, any award offer for that semester will be withdrawn and tuition remission cancelled. Students will be billed for tuition accordingly and will be responsible for payment in full.

Award Duration and Renewal

Student eligibility for awards is evaluated each semester. Student performance is evaluated at least once a year for renewal of award offers. However, each award may have unique eligibility, funding, duration and renewal circumstances. Students are responsible for understanding and following the terms and conditions of the particular award offer made to them. The Office of Graduate Studies should be consulted to determine individual terms and conditions. Award duration is based on calendar time, not on whether awards are full or partial.

- Students enrolled in master of science or masters of arts programs may not receive NJIT-funded, full or partial, assistantship or fellowship support for more than one academic year except in the cases listed below for B.S./M.S. students, and for U.S. nationals and permanent residents who are members of underrepresented groups. The academic year is defined as two semesters and one summer. The summer includes two award periods.
- Students enrolled in doctoral degree programs may not receive NJIT-funded, full or partial, assistantship or fellowship support for more than four academic years. This is defined as eight semesters and four summers.
- Students enrolled in the 97-credit Master of Architecture program may not receive NJIT-funded, full or partial assistantship or fellowship support for more than three academic years. Three academic years are defined as six semesters and three summers.
- Students enrolled in the Master in Infrastructure Planning program are considered as master of science students for award duration.
- Full-time master's students in the B.S./M.S. program are eligible to receive three semesters and one summer of financial support from internal funds.
- U.S. nationals and permanent residents enrolled in master of science programs who are members of underrepresented groups are eligible for three semesters and one summer of financial support from internal funds.
- Doctoral students who fail their qualifying examinations may not receive further awards from NJIT funds until they pass. Departments may request a review and continuation of their financial support status if they pass some but not all parts of qualifying examinations.
- When eligibility for NJIT-funded awards is completed, students may receive additional support from external sources. Check with the Office of Graduate Studies to obtain further details.
- Master's students are eligible to receive awards for a maximum of four semesters and two summers from all sources. This does not apply to students in the Master of Architecture program. Doctoral students are eligible to receive awards for a maximum of 10 semesters and 5 summers from all sources.
- No student may receive support for more than 12 semesters and 6 summers from any combination of sources or for any number of degrees.
- The university expects that doctoral students receiving NJIT-funded support move off that type of support to external source support no later than two years after the initiation of NJIT-funded support.

Resignations

Students who wish to resign from an award should inform their advisor and the Associate Provost for Graduate Studies at least one calendar month before the resignation is to take effect.

Students who resign during a semester will not be eligible for tuition remission for that semester. The semester in which the resignation is received is counted as a supported semester when determining award renewals.

Taxation of Stipends and Awards

The Internal Revenue Service requires that stipends and awards be taxed at the source, even if students are eligible for a tax refund. All students are exempt from Social Security taxes. Tuition and fee remissions are not subject to tax withholding.

Students should contact the Payroll Office for tax information and information about exemption from Social Security taxes. International students should contact the Payroll Office and the Office of International Students for information on tax treaties.

Tuition Remission

Tuition Remission Processing

All students receive bills for tuition. The bill statements for students receiving tuition remission and fees, if applicable, are marked "Possible Tuition Remission." After expiration of the official withdrawal period, a credit for the tuition and fees should appear on the statement.

Students who pay tuition bills in full and then receive tuition remission can expect to receive a refund after expiration of the withdrawal period. Students receiving only partial tuition and fee awards are responsible for payment of the remaining tuition and fees and should pay these promptly. In particular, full-time students should ensure that they have continuous health insurance coverage by payment of appropriate fees. For full award recipients, awards should only cover tuition and eligible fees, and will not exceed the cost of tuition and fees with some exceptions for students on certain fellowships. Eligible fees do not include parking fees or matriculation fee.

Students who fail to pay their bills by the due date specified by the Bursar will be assessed a late penalty fee. For more information, go to njit.edu/bursar (http://www5.njit.edu/bursar/).

Credit Limitation

Awards do not cover tuition for courses that are not part of a student's degree program or courses not approved by their advisor. Students are responsible for payment for these courses.

Tuition remission is allowed for courses taken at other institutions in which there is a cross-registration agreement with NJIT. These courses must be part of the student's degree program and approved by the student's advisor.

A flat rate exists for a range of credits representative of full-time registration. Any credits over that range will not be included in tuition remission awards. Students will be billed for credits in excess of their awards.

Graduate Cooperative Education

Graduate students have the opportunity to work off-campus while studying full-time through the cooperative education program administered by the Office of Career Development Services (CDS). Policies on eligibility, application for participation, procedures, and required regular and co-op course registrations are defined in a detailed statement developed by the Graduate Studies Office (GSO), CDS, and the Office of International Students (OIS). This opportunity is especially valuable for international students, pursuing the Master's degree, and for some PhD students lacking other forms of support. CDS should be contacted by students interested in this option. Each year, a large number of international graduate students are involved in cooperative education under Curricular Practical Training. Students pursuing this option are required to be registered in specifically numbered graduate courses for co-op as defined in each program's course listing.

Tuition and Fees

2019-2020 Graduate Tuition & Fees

Tuition and Fees Assessed (per Semester)

In-State Tuition & Fees

Credits	Tuition	Fees	Total
1	1122.00	189.00	1311.00
1.5	1683.00	283.50	1966.50
2	2244.00	378.00	2622.00
3	3366.00	567.00	3933.00
4	4488.00	756.00	5244.00
5	5610.00	945.00	6555.00
6	6732.00	1134.00	7866.00
7	7854.00	1323.00	9177.00
8	8976.00	1512.00	10488.00
9	10098.00	1701.00	11799.00
10	11220.00	1890.00	13110.00
11	12342.00	2079.00	14421.00
12-19	10312.00	1602.00	11914.00

Out-of-State Tuition & Fees

Credits	Tuition	Fees	Total
1	1613.00	189.00	1802.00
1.5	2419.50	283.50	2703.00
2	3226.00	378.00	3604.00
3	4839.00	567.00	5406.00
4	6452.00	756.00	7208.00
5	8065.00	945.00	9010.00
6	9678.00	1134.00	10812.00
7	11291.00	1323.00	12614.00
8	12904.00	1512.00	14416.00
9	14517.00	1701.00	16218.00
10	16130.00	1890.00	18020.00
11	17743.00	2079.00	19822.00
12-19	15270.00	1602.00	16872.00

e-Tuition Program - $1307.00 per credit (applicable to Non-Resident, Graduate students)

Executive Management Program - $57,500.00/ Fall Cohort or Greater $67,000.00

Full-time students (9 credits or more) will be assessed a Health Insurance fee in the fall.

Additional credits above 19 are assessed at the appropriate per credit rate.

Full-Time status varies: 12 credits for billing purposes, 9 credits for academic and Financial Aid purposes.

The Schedule of Tuition and Fees has been carefully reviewed and has been subject of a public hearing as required by Law prior to the approval by NJIT's Board of Trustees. All fees are mandatory for Full-Time and Part-Time students and are considered non-negotiable.

Summer / Winter Session Fees
During the summer & winter sessions there is a flat fee of **$189.00** in lieu of the fees noted above. Full-time Tuition rates do not apply during the summer/winter sessions.

Additional Fees

Fee Amount	Fee Description
75.00	U/G Application/Readmit/N-Matric
120.00	Commencement Fee
160.00	Matriculation Fee
500.00	Late Payment Penalty
100.00	Late Registration Fee
50.00	Maintaining Registration Fee
75.00	Master's Thesis
100.00	Dissertation Fee
125.00	International Student Fee
100.00	Payment Plan Fee
346.53	Parking Full-time (per semester) - includes tax
194.06	Parking Part-time (per semester) - includes tax
490.00	On-Campus Resident Parking (per semester)
6.625%	Commuter Parking Tax
200.00	Optional Practical Training Application Fee
E-Transcript Fee	7
Health Insurance	1543.00

Campus Life and Student Services

The Campus Center is the hub of cultural, educational, and social activities for the NJIT community. The Campus Center staff provides students, faculty and staff with a relaxing environment where they can enjoy a meal, attend a meeting, study, watch a film, play a variety of games, participate in the many cultural, social, and educational activities offered, or just socialize with friends.

Student Services

The Division of Academic Support and Student Affairs **(**https://www.njit.edu/studentaffairs/welcome/**)** consists of a variety of offices and departments that offer a wealth of programming, services, and resources to NJIT students. The common thread that runs through Student Affairs is the commitment to enable all students in our community to fully participate in an engaging, healthy, active learning environment during their time at NJIT.

Office of Graduate Studies

The Office of Graduate Studies (http://engineering.njit.edu/) provides assistance to graduate students in academic matters, approves Master's thesis and Ph.D. dissertation document formats, and processes student support nominations for university-level assistantships, fellowships, and scholarships.

For newly admitted and entering graduate students, we are the best source of information about any aspect of graduate study at NJIT. If you are not sure who to ask or where to go, try us first.

NJIT has many unique characteristics that are attractive to students from New Jersey, the United States, and from around the world. We offer a variety of options for students to pursue programs at the Master's and Doctoral levels. Our programs provide flexibility and choice of full-time or part-time study. Several academic programs (master's and graduate certificates) are available online (https://www.njit.edu/online/).

NJIT is committed to diversity among its students, faculty, and staff. Research activities of faculty and students focus on cutting-edge technologies and their applications. Exciting opportunities for student research exist in the graduate degree granting departments of NJIT's five colleges.

- Newark College of Engineering (http://engineering.njit.edu/)
- College of Science and Liberal Arts (http://csla.njit.edu/cslaprograms/graduate.php)
- College of Computing Sciences (http://ccs.njit.edu/ccsprograms/graduate.php)
- School of Management (http://management.njit.edu/academics/graduate/)
- College of Architecture and Design (http://design.njit.edu/coadprograms/graduate-programs/)

NJIT is a community of modest size but with a major impact on technological graduate education. It ranks highly in diversity, research activity, quality of graduate programs, and number of awarded master's and doctoral degrees as well as graduate certificates. We are conveniently located near New York City, in the busiest transportation hub in the United States. We are the only public technological university in the New York-New Jersey metropolitan area and have many cooperative arrangements with other universities in the region.

For further information, please visit the Graduate Studies Office web site (https://www.njit.edu/graduatestudies/).

Career Services

Career Development Services (http://www.njit.edu/cds/) is a value–added contributor to the career planning and preparation of NJIT students and graduates. We are dedicated to continually improving our client services and to assuming leadership in the profession of career development.

Our Mission is fulfilled through assisting:

- Students in gaining a clear understanding of their career options and workplace requirements, in obtaining experiential learning opportunities in the private and public sectors, in developing job search and interviewing skills, and obtaining employment upon graduation;
- Alumni in refining their job search and interviewing skills, career objectives, gaining a clear understanding of their career options and workplace requirements, and obtaining meaningful employment in a specialty consistent with their education, experience, and personal goals;
- Faculty/staff in understanding the needs of employers and of the academic preparation and associated skills necessary for graduates, and thus influencing curricula content and academic advisement;
- Employers in staffing their organizations with qualified students, graduates, and alumni capable of filling their workforce needs, and in developing closer and more effective relationships with university staff;
- The community in linking students, alumni, faculty, and staff directly to service and civic engagement activities with organizations committed to improving the quality of life for New Jersey residents.

- New Jersey's economic and workforce development efforts through ready access to a highly skilled workforce, thereby reducing company expenses for new employee recruitment, staffing, and training; facilitating the transfer of technological knowledge to the workplace; and through stimulating the creation of new jobs.

The Digital Campus

Computing has become ubiquitous in 21st century life, changing the way we work and learn, and even the way we interact with each other. The importance and power of information technology are evident in every discipline at NJIT, particularly in the STEM disciplines, where cascading breakthroughs and advances in information technology, have created a new interdependence among engineering, the physical sciences, computer science and math, and the biomedical sciences. NJIT researchers are leveraging the power of computing and information technologies to meet tomorrow's challenges, to create the tools to help the digital world function, and to evaluate the impact of new technologies on society.

NJIT has built a 21st century digital campus to support teaching, learning research, and the administration of the university. At the heart of the digital campus is the NJIT Network, with over 19,000 connections throughout the campus' 38 buildings, supplemented with the NJIT Wireless Network that blankets the campus, connecting over 22,000 devices each semester. Both networks provide access to servers, storage arrays, a large software library (http://ist.njit.edu/software/), and other IT services within the NJIT Cloud, enabling students to immerse themselves in design, discovery, simulation and modeling, and research questions previously inaccessible. Examples include:

- Simulating the interaction of biomolecules and identifying promising leads for drug development;
- Modeling the consequences of various transportation and energy systems;
- Studying global social networks;
- Designing and building the next generation of software and applications;
- Practicing computational science alongside traditional approaches;
- Designing buildings and other artifacts that are environmentally responsible and resource efficient.

Highlander Pipeline (http://my.njit.edu/), the NJIT Portal, is the entry point for many NJIT Cloud services. Students conduct most routine business processes online (e.g. register for classes, accept financial aid, pay bills, etc.) via Highlander Pipeline. The NJIT Library (http://library.njit.edu) provides online access to 27 full-text databases, over 33,500 electronic journals and more than 27,700 electronic books. A centralized "search all" portal delivers a single search experience of all electronic library resources.

Classrooms and other learning spaces at NJIT are all network enabled and equipped with modern projection devices, display panels, and other collaborative technologies to facilitate engagement and collaboration among faculty and groups of students. Many classes leverage video conferencing, lecture archival, learning management, and online discussion systems, allowing faculty and students to participate independent of time and place – converging the physical and virtual classrooms.

Students can BYOD ("bring your own device") or use any of the hundreds of workstations in public-access computer labs or specialized academic department facilities across the campus. A healthy mix of Windows, Mac, and Linux workstations support the diverse needs of a technological research university.

The Tartan High Performance Computing Initiative provides NJIT researchers the broad range of centralized computational and data storage resources necessary to conduct computationally-intensive research. With over 3,200 CPU cores and 26,000 GPU cores, Tartan provides researchers with local resources capable of supporting leading edge research. A separate Hadoop cluster provides the resources for managing and analyzing very large data sets, commonly referred to as "big data."

For additional information on IT services available at NJIT, visit the Home page of the Information Services & Technology (IST) Division (http://ist.njit.edu/).

Library Services

The Robert W. Van Houten Library (http://library.njit.edu/), NJIT's university library, is located in the Central Avenue Building (CAB), a facility for studying, researching, and browsing print and online resources. In 1997, the Van Houten Library opened the Information Commons, a computer lab with access to the internet and a wide range of electronic resources. Today, there are over 120 computer workstations and wireless access throughout the building.

The Barbara and Leonard Littman Architecture & Design Library (http://archlib.njit.edu/), a branch of the university's library is located in Weston Hall. Littman Library maintains a core collection of architecture, art and design information materials: books, journals, and various media. Maps, architectural drawings and models are accessible in the Littman Library, which also incorporates the Digital Scholarship Lab and Materials Library - a collection of materials samples.

Collection

The library collection comprises over 390,000 volumes of books, journals, conference proceedings, reports, dissertations, and theses. The libraries spend over 90% of its materials budget to acquire electronic resources to full-text content that are accessible anytime and anywhere. Electronic resources include ACM Digital Library, Academic Search Premier, Avery Index, Business Source Premier, Factiva, IEEE Xplore, New York Times Online, ProQuest Academic Complete electronic books, Science Direct, Scopus, SciFinder Scholar, SPIE Digital Library, SpringerLink (includes Lecture Notes in Computer Science), Wiley Online Library and many more (http://library.njit.edu/resources.php).

Getting Started

Access to print and electronic resources starts at the library home page, http://library.njit.edu (http://library.njit.edu/). Subject access to the journal literature in engineering, science, computer science, management, architecture, and other subject areas is provided by a variety of electronic databases.

Learning Space

The library strives to help students do their best work by providing a variety of individual and collaborative study spaces, including designated quiet study areas. See more about library services (http://library.njit.edu/services/).

Research and Instruction

Professional librarians provide instruction and consultation in all subject areas to enhance the students, faculty, and staff' ability to connect efficiently with needed information. Help is available in person, by phone or via email, and through chat (http://library.njit.edu/researchhelpdesk/askus.php) during selected hours.

Resources Beyond NJIT

Students, faculty, and staff may supplement NJIT library resources by borrowing material from the Rutgers University– John Cotton Dana Library, the Newark Public Library, the George F. Smith Library of the Health Sciences, and the other state colleges and university of New Jersey. Interlibrary Loan and Document Delivery Services (http://library.njit.edu/services/illiad.php) can also bring needed materials to our researchers from anywhere in the world.

Special Collections and Archives

Included among NJIT's information resources are the university's historical archive for items developed and manufactured by Edward Weston--scientist, a prolific inventor, and a founding member of the board of trustees of the university. The university library maintains a collection of Dr. Weston's books, papers and drawings in the Rare Book room that is available to scholars and others interested in the history of science and technology.

Contact Us

Van Houten Library	Littman Architecture & Design Library
Central Avenue Building	Weston Hall
(973) 596-3210	(973) 596-3083
http://library.njit.edu (http://library.njit.edu/)	http://archlib.njit.edu (http://archlib.njit.edu/)

Residence Life

Almost 2000 students live on campus in five coed residence halls and the Greek Village. More than 50 percent of first-year students live on campus. First-year students live in Cypress, Honors and Redwood Halls. Upper-class students live in every building. Rooms are fully furnished (bed, desk, chair, closet, dresser), air-conditioned, wireless and wired for Internet and offer cable TV including HBO and Residence Life Cinema (current movie offerings). Each hall has common areas and facilities including lounges, study areas, kitchens and laundry rooms. Snack and soda machines, recreational equipment (pool, pingpong, large screen televisions, etc.), and mail service Monday-Friday are also provided.

Cypress Hall is a coed facility that houses 418 first-year, upper-class, and graduate students in single and double rooms. Suites are comprised of two bedrooms and a shared bathroom and foyer.

Greek Village is a coed facility that houses 192 upper-class and graduate students in eight houses. Both fraternity and sorority members and nonmembers live in double rooms. Suites are comprised of two bedrooms and share bathroom. The buildings have a kitchen and dining and living area.

Honors Residence is a coed facility housing 360 first-year, upper-class and graduate students in single and double rooms. Suites have a shared bathroom. The building features a dining facility, convenience store and fitness center.

Laurel Hall is a coed facility that houses 580 upper-class and graduate students in two-room suites. Suites consist of students living in single and double rooms, sharing a bathroom and foyer.

Oak Hall is a coed apartment facility that houses 186 full-time upper-class and graduate students in both suite-style rooms and apartments. Each suite-style room is double occupancy with a kitchenette and shared bathroom. Each apartment has a kitchen, living room and bathroom. The eighth floor is designated for graduate students.

Redwood Hall is a coed facility that houses 185 first-year and upper-class students living in single and double rooms.

NJIT students use electronic cards for access to the residence halls. Desk attendants are on duty 24 hours a day and provide security for the residence halls by monitoring hall entrances and swiping resident IDs. All guests must have a valid photo ID and must be signed into the residence hall by a resident host. All guests must be accompanied by their hosts at all times.

Residence Life has staff on-duty in each hall during non-business hours. In addition, NJIT’s Department of Public Safety Office police and public safety officers patrol campus 24 hours a day. Patrols are conducted on foot, in cars and on bicycles. Additionally, campus emergency phones are located on campus. Rooftop surveillance cameras are mounted throughout campus and monitored around the clock.

Once you have been admitted to NJIT, you can complete the Housing Application and Contract: https://www5.njit.edu/reslife/apply.php. A $50 nonrefundable deposit may be required and can be paid by check/money order payable to NJIT. Check/money orders must be sent to the Residence Life Office, 180 Bleeker Street, Newark, NJ 07103-3514. You will receive a confirmation in your NJIT email immediately after you submit your application online.

Applications for first-year students received by May 1 are guaranteed housing. After May 1, housing is assigned based on the distance you live from campus, need, and date of application.

For additional information please view our website: http://www.njit.edu/reslife (http://www.njit.edu/reslife/) or contact us via email reslife@njit.edu or call 973.596.3039.

Food Services

The Dining facilities are located in the Campus Center and the first floor of the Honors Residence. NJIT's private food services vendor, Gourmet Dining Services, operates all of the dining options on campus. Meal plan options include both Continuous Dining and Flex Dollar options. The Continuous Dining meal plans, A-E, features continuous dining with unlimited returns during all of the posted hours. Flex dollars can be used at Continuous Dining (for those without meal plans or only have flex), Korner Kilt C Store, Trattoria, Tech Café, Café Spice, Grains, Leafs, Taco Bell, The Grill, Highlander Pub, Village Market, and Warren Street Café. For hours and a complete listing of what is available via flex, please check https://njitecash-sp.transactcampus.com/eaccounts/AnonymousHome.aspx.

Continuing Professional Education

NJIT's Continuing Professional Education provides enriching career-long learning opportunities through extension programs, Online Learning, graduate certificates, and professional development training for individuals and company employees.

Professional development programs include short courses, certificates and license reviews, with some leading to the award of continuing education units (CEUs). The CEU is used nationally to document the type, quality and duration of study. In general, a CEU is defined as being equal to classroom hours. All professional development courses can be adapted to meet a particular organization’s needs and conducted as a custom-designed training program at a company site. For more than 50 years, NJIT has been designing and conducting high-quality professional development programs that meet organizations’ business needs. Since 1990, NJIT has trained over 63,000 professionals as part of over 550 training initiatives for 300 different companies conducting business in New Jersey.

For further information contact cpe@njit.edu.

Online Learning

Online Learning

Online Learning offers numerous graduate degrees, select Graduate Certificates, and graduate courses in many disciplines including communication, computer science, information systems, information technology, humanities, management, and engineering management. Online Learning offerings can be viewed at http://www5.njit.edu/online (http://www5.njit.edu/online/).

Online Learning provides students the opportunity to earn college credit through enrollment in online electronic-based courses. These courses are virtual learning communities with instructor-led online classrooms that utilize various technologies such as Moodle (http://moodle.njit.edu) for presenting course material, online quizzes, asynchronous and synchronous communication. Online courses are flexible and rigorous educational experiences suited to motivated students.

The program's reach is worldwide. Course material can be accessed through the Internet via learning management systems utilizing multimedia presentations.

Online Learning furnishes a convenient alternative to graduate distance learners and students who have scheduling conflicts. For more information, contact the Office of Graduate Studies at 973-596-3462 or email online@njit.edu.

Graduate Programs

Graduate Studies

NJIT offers advanced studies in numerous disciplines leading to master's degrees, doctoral degrees (http://catalog.njit.edu/archive/2019-2020/programs/) and graduate certificates (https://www.njit.edu/graduatestudies/degree-programs/graduatecertificates/). Programs are available to full-time students and to working professionals who may be interested in part-time study. Several master's degree programs and graduate certificates are fully available online (https://www.njit.edu/online/). Some programs are offered jointly or in cooperation with Rutgers-Newark and with RBHS as part of continuing collaborations. Graduate programs at NJIT are overseen by the Office of Graduate Studies (https://www.njit.edu/graduatestudies/), Fenster Hall, Room 140, 973-596-3462.

Graduate students are involved in the university's extensive research activities through association with renowned faculty, research centers and research laboratories. Financial support (http://www5.njit.edu/graduatestudies/finaid.php) is available to eligible Ph.D. students in the form of teaching assistantships and research assistantships. Some opportunities are also available to eligible Master's students for service-based or fellowship support. For information about these opportunities, students are encouraged to contact their academic departments.

Graduate Degrees

All doctoral programs lead to the Doctor of Philosophy (PhD) degree. Master's programs lead to the Master of Science (MS), Master of Arts (MA), Master of Arts in Teaching (MAT), Master of Architecture (M.Arch.), Master in Infrastructure Planning (MIP), or the Master of Business Administration (MBA) degree. Numerous accelerated degree options (https://www.njit.edu/graduatestudies/degree-programs/bs-ms/) exist that allow dual use of some courses in one degree program toward a second degree program. The Office of Graduate Studies (https://www.njit.edu/graduatestudies/) may be consulted about accelerated degree options such as BS/MS, MS/MS and other similar combinations.

The Collaborative Doctorate

This PhD student option is designed to meet the workforce needs of the knowledge-dependent global economy. The Collaborative Ph.D. program is designed for engineers, executives, scientists, military personnel, state and federal government employees, and educators who want to pursue a Ph.D. degree part-time while continuing full-time employment. The admission and academic requirements are the same as for NJIT’s regular Ph.D. programs but the collaborative nature of the program allows participants to draw on the combined expertise and resources of the university and their employer. The dissertation research of students in the collaborative Ph.D. is expected to produce original contributions to science, engineering, technology or management and satisfy all quality criteria set by the dissertation committee. The student’s main dissertation advisor is an NJIT faculty member while the research may meet the needs of the student and employer in advancing knowledge in the chosen discipline.

To apply to the collaborative Ph.D. program, candidates must have been employed in their specified field for at least a year. NJIT’s standard criteria for admission will be applied but prior work-related research activity, publications, and honors will also be considered in evaluating prospective participants.

Details about this opportunity are available at http://catalog.njit.edu/graduate/academic-policies-procedures/collaborative-doctorate/ (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/collaborative-doctorate/).

Graduate Certificates

NJIT's graduate certificates give students the opportunity to:
(a) improve their skills in their current occupation by developing expertise in advanced topics,
(b) acquire knowledge to pursue new careers, or
(c) explore emerging fields before committing to relevant master’s degree programs that require more courses.

Many students pursue a graduate certificate for personal growth or career development.

Each certificate program contains 4 graduate courses (equivalent to a total of 12 graduate credits) that are normally part of the curriculum for a 30-credit Master's degree program. After successful completion of a graduate certificate, a student may decide to continue studying at NJIT towards the corresponding Master's degree by taking advantage of rapid matriculated acceptance and eventual acquisition of two credentials (essentially for the price of the Master’s degree).

College of Architecture and Design

The College of Architecture and Design is comprised of the nationally known New Jersey School of Architecture and the newly created School of Art + Design. The College brings together under one roof Architects, Planners, Designers, and Artists.

Learning and collaborating with an award-winning faculty, this fosters a vibrant intellectual and creative atmosphere. We prize imagination and adventurous exploration.

There are ample opportunities for cross-pollination of ideas and interdisciplinary interaction. Using a nuanced blend of intuitive exploration and rigorous logic, students in the College of Architecture and Design work today to conceive and present new possibilities to help address tomorrow’s challenges.

Programs

- Architecture - M.Arch. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march/)
- Architecture - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/ms/)
- Infrastructure Planning - M.I.P. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/infrastructure-planning-masters/)

Double Majors (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/special-programs/)

- Architecture (professional, or post-professional) - M.Arch. and Infrastructure Planning - M.I.P. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-mip/)
- Architecture (professional, or post-professional) - M.Arch. and Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-management-ms/)
- Architecture (professional, or post-professional) - M.Arch. and Civil Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-civil-engineering-ms/)

Urban Systems - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/urban-systems-phd/)

College of Architecture and Design Courses

ARCH 500G. Advanced Architectural Graphics. 3 credits, 3 contact hours.
Introductory computer science with applications in computer graphics for architecture. Emphasizes programming methodology using a high-level language as the vehicle to illustrate concepts. Basic concepts of computer systems, software engineering, algorithm design, programming languages, and data abstraction, with applications.

ARCH 501G. Architectural Design I. 6 credits, 12 contact hours.
Prerequisite: graduate level standing. Core Studio. Fundamentals of architectural design. Sequence of projects explore two- and three-dimensional design. Choice of form and aesthetics is related to spatial resolution of function and context. Design as a representational medium is emphasized. Taken concurrently with ARCH 555G.

ARCH 502G. Architectural Design II. 6 credits, 12 contact hours.
Prerequisites: ARCH 501G, ARCH 528G, ARCH 541G, ARCH 555G. Core Studio. Extends the knowledge of design, basic concepts and ideas introduced in ARCH 501G. Emphasis is on developing technical drawing, and model-making skills. Also covered are two- and three-dimensional composition. Links to the history and theory sequence are made.

ARCH 503G. Architectural Design III. 6 credits, 12 contact hours.
Prerequisites: ARCH 500G, ARCH 502G, ARCH 529G, ARCH 543G, and ARCH 545G. Core Studio, Intermediate design studio. Introduction to structure. Properties of materials both physical and in the abstract. Builds on knowledge gained from construction and structures courses, spatial demands and design possibilities of different structural systems. Design of structure type, model and context, and comparisons of building typology for rational structure. Drawing and its role in design thinking.

ARCH 504G. Architectural Design IV. 6 credits, 12 contact hours.
Prerequisites: ARCH 503G, ARCH 542G, ARCH 544G. ARCH 548G. Corequisite:547G. Second semester intermediate design studio. Design of buildings and integration of systems, physical and conceptual. Design methodology generates new information on buildings as coherent assemblies of systems. Also covers analysis and synthesis of form and introduction to applications of computer-assisted design (CAD). Preparation of design portfolio will complete core studio sequence.

ARCH 505G. Advanced Design Options I. 6 credits, 12 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 506. Advanced Design Options II. 5 credits, 13 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 506G. Advanced Design Options II. 6 credits, 12 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 507G. Advanced Design Options III. 6 credits, 13 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 510. Co-op Work Experience III. 0 credits, 3 contact hours.
Restriction: Approval of the school and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Students are required to complete and present miterm and final projects and/or reports. A designated faculty member monitors and evaluates the student's work and project.

ARCH 513G. Structures III. 3 credits, 3 contact hours.
Prerequisite: ARCH 512G. Review of methods and procedures for choosing structural systems. Overview of differences among wood, steel and concrete systems. Students are introduced to complex structural behavior, prestressed concrete and new structural technology.

ARCH 527G. Situating Prac:Thrshds of Arch. 3 credits, 3 contact hours.
Restriction: Enrolment in Masters of Architecture Program or by permission of instructor. Western architectural theory dating from Vitruvius to the present time. Examines critical texts and studies related building and projects.

ARCH 528G. History of Architecture I. 3 credits, 3 contact hours.
Restriction: graduate level standing. Introduction to the history of architecture. Emphasis on classical architecture from antiquity to the modern period. Evolution of the various themes and theories that underlie western architecture is presented chronologically.

ARCH 529G. History of Architecture II. 3 credits, 3 contact hours.
Prerequisite: ARCH 528G. Continuation of ARCH 528G. Introduces concepts of modernism and brings the history of western architecture to the contemporary period.

ARCH 530. Methodologies of Architectural History, Theory and Criticism. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. A seminar examining the salient methodologies of architectural history, theory and criticism. Structured around a series of critical texts, with each set of core readings intended to provide a basis for analyzing and assessing the approach in question.

ARCH 531A. History of Renaissance Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An examination of the development of Renaissance architecture and urban design in Italy and elsewhere in Europe. The re-emergence of the classical tradition is considered within the context of social, political and economic developments as well as formal intentions.

ARCH 531B. History of Baroque Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An investigation of architectural development from the 17th and 18th centuries in Europe and Latin America, including consideration of stylistic variations, social and political factors, and trends in garden and urban design.

ARCH 531C. History of Modern Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. A study of major tendencies of architectural theory and practice from the mid-19th to the mid-20th centuries. Formal and stylistic transformation is considered in relation to theoretical intentions as well as social, cultural, and technical developments.

ARCH 531D. History of American Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An investigation of the guiding ideals and dominant stylistic trends in American architecture and planning from colonial times to the mid-20th century. Critical shifts in conception and scope of architectural production considered in relation to the prevailing cultural, socio-economic, and technical contexts out of which they evolved.

ARCH 531E. History of Non-Western Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An examination of major architectural traditions of China, Japan, Southeastern Asia, India, and the Middle East. Each area is considered with reference to a conceptual, iconographic and stylistic paradigm that evolved from a particular historical context.

ARCH 531F. Thresholds of Architectural Theory. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. A seminar that investigates key thresholds of Western architectural theory, from Vitruvius to Robert Venturi, with emphasis on examining the corresponding critical theoretical texts and related didactic buildings and projects.

ARCH 531H. Aspects of Urban Form. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An examination of the major forms and patterns of urban development from classical antiquity to the 20th century, considered in relation to the changing conceptions of the city as well as cultural, socio-economic, and political development.

ARCH 533. Case Studies in Architectural Creativity. 3 credits, 3 contact hours.
Prerequisite: ARCH 364. Considers creativity in architecture from psychological, philosophical and autobiographical perspectives. The buildings, writings and lives of contemporary architects are discussed in the context of general theories of creativity. Each student chooses an individual architect noted for creative accomplishments and prepares a case study of his or her life.

ARCH 534. History of Architectural Technology. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. Survey of the development of building methods and materials. Impact of structural and environmental technology on architectural form and the design process. The role of technology in contemporary architectural theory and practice, including the modern movement, is emphasized.

ARCH 535. History of Architectural Ideas. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. Discusses seminal architectural ideas in the western world from Vitruvius to the present day. Read books written by leading architectural theorists and analyze them in detail.

ARCH 536. Landscape and American Culture. 3 credits, 3 contact hours.
As in architecture, the parallel discipline of landscape architecture involves artistic intention set in conjunction with utilitarian concerns. As such, designs on the land include the integration of the arts and sciences of human culture with nature. Discusses landscape as a manifestation of American culture.

ARCH 537. Advanced Structures. 3 credits, 3 contact hours.
Covers advanced material in structures related to steel and wood design including: steel industrial buildings, rigid frames and earthquake design, wood structures under axial loads, and combined bending and axial loads.

ARCH 538. Sustainable Architecture. 3 credits, 3 contact hours.
Follows two precepts: accepting responsibility for the consequences of design decisions upon human well-being, and the long-term viability of natural systems. Topics include sustainable site design and development, environmentally sensitive building materials, lifecycle cost benefit analysis of building systems, and adaptive reuse.

ARCH 540. Acoustics. 3 credits, 3 contact hours.
Prerequisite: ARCH 327. Architectural acoustics: how we hear, physics of sound and materials, aesthetics of design and the processes of construction. Audible sounds, their interaction, perception of echo and directional hearing are applied to interior and exterior building transmission, room acoustics, and setting acceptable acoustical environments.

ARCH 541. Material Systems in Design. 3 credits, 4 contact hours.
Prerequisite:4th year undergraduate standing or approval from instructor This seminar will allow students to exam material systems that give design agency to matter as a creative and technical force in the making of architecture. In doing so, it will provide students an opportunity to understand and explore the role material matters play in comtemporary architectural theory and praxis. focused on the exploration and understanding og material systems, this course will provide students with the intellectual underpinnings for the re-conceptionalization of matter within thier own design processes.

ARCH 541G. Construction I. 3 credits, 3 contact hours.
This course is an introductory survey of the general principles and application of Sustainable Design, Site Systems, Structural Systems, Environmental Systems, Envelope Systems, Materials and Assembly Systems. This course will primarily focus on low-rise wood and steel structures.

ARCH 542G. Construction II. 3 credits, 3 contact hours.
Prerequisite: ARCH 541G This course is an introductory survey of the interrelationship of the principles and applications of Sustainable Design, Site Design, Structural Systems, Environmental Systems, Envelope Systems and Materials and Assembly Systems. This course will primarily focus on low and medium-rise concrete and masonry structures and is coordinated with a studio design/build experience.

ARCH 543. Lighting. 3 credits, 3 contact hours.
Prerequisites: ARCH 327 or INT 222. Explores, through modeling and calculation, the means by which architectural form and detail influence the luminous environment. Perceptual responses such as visual comfort and delight are examined. Topics include daylighting footprints, model design and testing, and computer-assisted light level analysis. Areas of investigation include the relationship between daylight and electric light in architecture; the variations of light with time; analysis of seasonal and weather differences; role of task in lighting strategies; and means of control for light quantity and quality.

ARCH 543G. Environmental Control Systems I. 3 credits, 3 contact hours.
An introductory survey of the basic principles of building, environmental control, and service systems as these relate to the building envelope. This course will primarily cover thermal enclosure, climate modification, environmental systems, energy use, and sustainable design. It also introduces the principles of health and safety in the design of buildings.

ARCH 544G. Environmental Control Systems II. 3 credits, 3 contact hours.
This is an intermediate course focusing on the understanding of the principles, performance criteria, and applications of environmental and building service systems including lighting, acoustical, plumbing, electrical, vertical transportations, egress, communication, security, and fire protection systems.

ARCH 545. Case Studies in Architectural Technology. 3 credits, 3 contact hours.
Prerequisite: senior standing. Technological systems involved in the construction and use of buildings. Students conduct in-depth investigation of technology-related problems in architecture and construction. Case study method is used. Construction documents and reports are analyzed. Field visits are required.

ARCH 545G. Structures I. 3 credits, 3 contact hours.
This is an intermediate course focusing on the principles of structural behavior in withstanding gravity and lateral forces and on the evolution, range, and appropriate application of structural systems and the criteria for selecting various structural systems in contemporary architecture. Specific architectural procedents from the 20th century are used as validating examples.

ARCH 546. Designing and Optimizing the Building Enclosure. 3 credits, 3 contact hours.
Prerequisite: Any 100 level CS course except CS 100. Considers the building envelope, the boundary dividing the inside of a structure from the outside environment. Study and design optimal enclosures considering energy exchange, the relationship between energy and light, and life cycle costs.

ARCH 546G. Structures: High Rise and Special Applications. 3 credits, 3 contact hours.
Prerequisite: 545G. This is an advanced course focusing on the integration of all building systems including new materials and methods as they relate to high-rise structures and other specialty building types.

ARCH 547. Special Topics in Computer Applications. 3 credits, 3 contact hours.
Prerequisite: senior standing. Evaluation, utilization, and development of computer programs for analysis, simulation and information management. Programs range from energy analysis, building structures analysis, and mechanical systems design to spatial allocation, graphics and computer-aided design. Different theories of information transformation and delivery used in terms of architectural applications. Course hardware ranges from computer-aided design and drafting systems, through micro and mini, to mainframe computers.

ARCH 547G. 4D Integration. 3 credits, 3 contact hours.
Prerequisites: ARCH 542G, ARCH 544G, ARCH 548G. Co-requisite: ARCH 504G. This is a required, advanced design course that uses in-depth, detailed case studies of various construction types, from small scale to large, from simple to complex, to illustrate the totality of building systems integration. In conjunction with site visits, coursework will employ software to examine construction sequences, building components and shop drawings and their relationship to the design processes.

ARCH 548G. Structures II. 3 credits, 3 contact hours.
Prerequisite: ARCG 545G. This is an advanced course dealing with structural computation that will conclude with rigorous case study investigation of hybrid and complex structural systems.

ARCH 549. Life Safety Issues in Contemporary Buildings. 3 credits, 3 contact hours.
Prerequisites: ARCH 327 or INT 222. A variety of life safety and comfort situations studied in terms of specific building types. Topics include building evacuation, compartmentalization, fire fighting and suppression, evaluation and testing of new building materials and systems, systems control and management. Special emphasis is on such building types as multi-use, high-density, schools, hospitals, and other institutional categories.

ARCH 552. Real Estate Analysis for Architects. 3 credits, 3 contact hours.
Introduction to the economic, financial and political aspects of real estate and their effect on architectural decision-making. Topics include needs assessment, real estate appraisal, financial instruments, regulations and real estate, design as value-adding, and the effect of tax policies on real estate development.

ARCH 555G. Architectural Graphics. 3 credits, 5 contact hours.
Restriction: graduate level standing. Documentary, descriptive and denotative media are introduced. Also covers methods of representation, delineation and reproduction. Skills are developed in technical drawing, perspective construction, projections, and format design. Taken concurrently with ARCH 501G.

ARCH 556. Systems Approach to Design and Construction. 3 credits, 3 contact hours.
Lectures, case studies and student projects on understanding human aspiration and needs through design. Topics include land, finance, management, technology, and labor.

ARCH 557. Problems in Modern Housing. 3 credits, 3 contact hours.
Prerequisite: ARCH 382 Historical approach places housing in its social, economic, and political context. Attempts to provide decent, affordable and well-designed housing for broad segments of society are examined. Dwelling is examined through analysis of proto-typical design solutions in urban environments.

ARCH 558. Professional Architectural Practice. 3 credits, 3 contact hours.
Prerequisite: ARCH 364. A forum for examination of the structure and practices of the profession of architecture. The formal and informal relationships between architects, and between architects and clients, government officials, and consultants are studied. Basic principles of office management for the small and large architectural firm are introduced.

ARCH 559. Social Issues in Housing. 3 credits, 3 contact hours.
Lecture/seminar explores the historical, economic, social, technological, and political basis for current American housing policy and practice. Examines government, community-based and private sector attempts, both failed and successful, at providing decent, affordable, and well-designed housing for broad segments of society. Student teams analyze and discuss, in a series of classroom debates, the housing and planning implications of controversial social problems from homelessness and racial segregation to caring for the elderly and people with HIV/AIDS with an emphasis on the role of the architect.

ARCH 561. Integrated Studio Seminar. 3 credits, 3 contact hours.
Prerequisite: ARCH 463. Corequisite: ARCH 564. Held in design studio each week, the lab consists of presentations by the instructor on relevant technical, building code, and life safety-issues as well as student exercises applying these principles to their integrated design studio project or to existing buildings.

ARCH 563. Options Studio III. 5 credits, 12 contact hours.
Prerequisites: ARCH 464, ARCH 423, ARCH 327 and ARCH 429. Studio methodology allows students to select from various building programs, the nature of design dealing with technology, environment and the social order.

ARCH 564. Integrated Design Studio. 5 credits, 12 contact hours.
Prerequisite: ARCH 463 Corequisite: ARCH 565 This Studio focuses on the student's ability to produce a comprehensive architectural project based on a building program and site that includes development of programmed spaces demonstrating an understanding of structural and environmental systems, building envelop systems, life-safety provisions, wall sections and building assemblies and the principles of sustainability. Lecture hour coordinates with studio subject matter. Course materials purchase required.

ARCH 565. Comprehensive Studio Lab. 1 credit, 1 contact hour.
Prerequisite: ARCH 464 Corequisite: ARCH 563 or ARCH 564 Held in design studio each week the lab consists of presentations by the instructor on relevant technical and life safety issues and student excercises applying these principles to thier currecnt design studio project or to existing buildings.

ARCH 566. Advanced Architectural Design Studio. 5 credits, 12 contact hours.
Prerequisite: ARCH 564. This is an advanced architectural design studio, post Comprehensive Studio, studying contemporary design theories, design methods and construction technologies. Emphasis is placed upon independent design research as it relates to the broad range of architectural practice. Exploratory and experimental architectural projects are the focus of the course.

ARCH 569G. Building and Development. 3 credits, 3 contact hours.
Familiarization with the larger process of building production, of which architecture is one important part. Focus on the role of the architect in the areas of current building development: an examination of how redefinition or change might improve the process. Lectures deal with all factors of the building process and interviews with the various actors involved in designing, approving, financing and making buildings. Students have various assignments including a major term project.

ARCH 571. Everyday Life in the Public Realm. 3 credits, 3 contact hours.
A significant portion of everyday life takes place in the public realm of streets, sidewalks, parks, transit stations, government buildings, commercial establishments, and cultural institutions. Focuses on recent descriptions and critiques of public space and proposals for change.

ARCH 572. Architecture and Social Change. 3 credits, 3 contact hours.
Architectural form is analyzed in relation to political, economic and technological change, and change in social values. Buildings and other designed environments such as parks, streets and neighborhoods are studied relative to the social processes and institutions that generate and transform them. The role of the design professions in initiating or supporting change also is considered.

ARCH 573. Technologies for Community and Urban Design. 3 credits, 3 contact hours.
Advanced and traditional technologies analyzed with regard to their role in community and city design, construction and reconstruction. Emphasis on technological systems influencing location, configuration and use. Examples are infrastructures, communication systems and construction technologies. Develops skills in using methods to evaluate alternative technologies relative to their social, economic and physical promise, problems and feasibility.

ARCH 574. Case Studies in Community and Urban Design. 3 credits, 3 contact hours.
In-depth investigation of specific real-world problems of urban or community design carried out using case method approach. Current practices in the U.S. and other countries studied using interviews with designers, developers, community groups and government agencies. Site visits, reports and other documents provide important sources of information. Final report with supporting documentation required.

ARCH 576. Architecture of Utopia. 3 credits, 3 contact hours.
Seminar for the review of utopian projects that have attempted to embody and strengthen social ideas through transformations in the structuring of space. Architectural implications of different literary and philosophical utopias analyzed with an emphasis on those experimental proposals which were realized, in whole or in part, in built form.

ARCH 579G. Professional Architectural Practice. 3 credits, 3 contact hours.
Restriction: completion of M.Arch. core sequence. Review of the formal, informal, legal, and ethical obligations of the professional architect. Traditional relationships among the architect, clients, engineers and other participants in the design and building industry are studied. Principles of office management and problems of liability are introduced. Also fulfills core requirement of dual degree option for M.Arch./Master of Science in Management.

ARCH 583. ST:. 3 credits, 3 contact hours.
Group investigation of problem of special interest in architecture.

ARCH 588. Architoons. 3 credits, 3 contact hours.
Prerequisite: ARCH 364. Through the medium of film, applies literary devices to architectural contexts, including caricature, parody, lampoon, satire and farce. Studies historical and contemporary animations and short films for their treatment of meaning, story line and sequence, timing, environmental and psychological mood, atmosphere and emotion. Using 3-D modeling and animation software, each student produces an animated short subject illustrating an architectural principle or providing a humorous look at architectural history and theory.

ARCH 591. Independent Study. 1 credit, 1 contact hour.

ARCH 592. Independent Study. 2 credits, 2 contact hours.

ARCH 593. Independent Study. 3 credits, 3 contact hours.

ARCH 619. Architectural Photography. 3 credits, 3 contact hours.
Prerequisites: ARCH 501G, ARCH 502G, ARCH 503G. Photography for architectural presentations and portfolios. Lectures include orientation on light and space, slide presentations, and the use of text to reinforce photographic material. Demonstrations include basic darkroom techniques, and methods to encourage experimentation in photography.

ARCH 630. Methodology of Architectural History, Theory and Criticism. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. This seminar is structured around notable readings on architectural history, theory and criticism to provide students with a sound basis for critical analysis and assessment. It is recommended for students who select history and theory as their area of concentration.

ARCH 631A. History of Renaissance Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Development of architecture and urban design in Italy and elsewhere in Europe during the Renaissance: re-emergence of the classical Greek and Roman architectural tradition; social, political and economic developments; formal intentions and transformations in the 16th and 17th centuries.

ARCH 631B. History of Baroque Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. The emergence of baroque architecture and urban design in Rome in the 17th century; analysis of the works of Bernini, Borromini, Cortona and their contemporaries and successors through 1750. Development of baroque architecture elsewhere in Italy and Europe; late baroque and rococo; the advent of neo-classicism.

ARCH 631C. History of Modern Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Major tendencies in architectural theory and practice from the mid-19th to the mid-20th centuries. Formal and stylistic transformation considered in relation to theory, social, cultural, and technical developments.

ARCH 631D. History of American Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Aesthetic, social, cultural and technical developments in American architecture and planning, from colonial times to the mid-20th century.

ARCH 631E. History of Non-Western Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Examination of major architectural traditions and styles of China, Japan, Southeast Asia, India and the Middle East.

ARCH 634. History of Architectural Technology. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Survey of the development of building methods and materials. Impact of structural and environmental technology on architectural form and the design process. The role of technology in contemporary architectural theory and practice including the modern movement is emphasized. Recommended for students who select building science as their area of concentration.

ARCH 636. Methods of Urban History. 3 credits, 3 contact hours.
Prerequisite: Graduate status The seminar examines methods for conducting historically driven, interdisciplinary research on the built environment (with a focus on cities and suburbs) through the lens of architecture, landscape, geography, and material culture. Methodology is studied to inform the production of urban history and to frame historical perspectives on contemporary urban issues. Historiography and critical theory are key aspects of the study of urban history's methodologies. In addition to traditional historical methodologies, the course examines emerging digital humanities methodologies.

ARCH 637. Teaching Sem:Arch Pedagogies. 3 credits, 3 contact hours.
Prerequisite: Graduate status This course is a graduate seminar that introduces students to key issues in contemporary pedagogy, understood as the art, craft, theory and practice of teaching. The course examines principles and constructs of teaching and education, as well as their pragmatics and practicalities. The main focus of the course is architectural education with discussions informed by diverse issues such as technology and the information revolution and multiculturalism and globalism.

ARCH 640. Acoustics. 3 credits, 3 contact hours.
Restriction: completion of core sequence or equivalent. Architectural acoustics: how we hear, physics of sound and materials, aesthetics of design and the processes of construction. Audible sounds, their interaction, perception of echo and directional hearing are applied to interior and exterior building transmission, room acoustics, and setting acceptable acoustical environments.

ARCH 641. Experiments In Structural Form. 3 credits, 3 contact hours.
Restriction: completion of core sequence or equivalent. Architectural form through model design, construction and testing of minimum structures, including elements of soap film study, orthogonal and diagonal grids, design of tension grids through deflection loading, photoelastic models and calculation. Also compares geometric systems, patterning and proportion, symmetry, asymmetry, relative size, nesting, linearity and spiral orders, rectilinear patterns, and randomness in architectural structure and form.

ARCH 642. Digital Modeling & Fabrication. 3 credits, 3 contact hours.
Prerequisite: ARCH 501G This is a 3-credit seminar course for graduate students exploring advanced 3-dimensional computer modeling techniques and data export for assembly and fabrication to various computer numerically controlled (CNC) hardware available at the School of Architecture. Specifically, students engage in NURBS and solid modeling using Rhinoceros 3D and export data through various Rhino plug-ins including RhinoCAM, which writes G- and M- Codes for 2 and 3D milling operations.

ARCH 643. Lighting. 3 credits, 4 contact hours.
Prerequisites: ARCH 501G and ARCH 502G. Through modeling and calculation, influence of the luminous environment on architectural form and detail. Perceptions of visual comfort and daylight are examined. Topics include daylighting footprints, model design and testing, and computer-assisted, light-level analysis. Relationship between daylight and artificial light in architecture, variations of light with time, analysis of seasonal and weather differences, role of task in lighting strategies, and means of control for light quantity and quality.

ARCH 645. Case Studies in Architectural Technology. 3 credits, 3 contact hours.
Restriction: completion of core sequence. Case-study method used for in-depth investigation of the relationship among various technological systems in a building and technologically-related problems in architecture and construction.

ARCH 646. Designing and Optimizing the Building Enclosure. 3 credits, 3 contact hours.
Restriction: completion of core sequence. Considers the "building envelope," the boundary dividing the inside of a structure from the outside environment. Students study and design optimal enclosures considering energy exchange, the relationship between energy and lighting, and life cycle costs.

ARCH 647. Special Topics in Computer Applications. 3 credits, 5 contact hours.
Restriction: completion of core sequence. Evaluation and use of computer graphics hardware and software for architectural applications. Focus is on computers as tools, operating systems and methods of data manipulation. Two- and three-dimensional modeling software are discussed, and assignments using such software are given to provide understanding of the modeling of built environments.

ARCH 649. Life Safety Issues in Contemporary Buildings. 3 credits, 3 contact hours.
Restriction: completion of core sequence. A variety of life safety and comfort situations are studied in different building types. Topics include building evacuation, compartmentalizing, fire fighting and suppression, evaluation and testing of new building materials and systems, systems control and management. Special attention is placed on multi-use, high-density buildings.

ARCH 650. Economy Of Building. 3 credits, 3 contact hours.
Restriction: completion of core sequence or equivalent. Economic consequences of design decisions. Topics include: relationship among economy, efficiency and quality; life-cycle cost of design; improving the economy of building processes and products through innovation; and environmental concerns. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

ARCH 651. Real Estate Analysis for Architects. 3 credits, 3 contact hours.
Restriction: completion of core sequence. Introduction to the economic, financial and political aspects of real estate and their effect on architectural decision-making. Topics include: needs assessment, real estate appraisal, financial instruments, regulations and real estate, design as value-adding, and the effect of tax policies on real estate development. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

ARCH 652. Architectural Project Management. 3 credits, 3 contact hours.
Prerequisite: ARCH 579G. Restriction: completion of core sequence. Management of architectural projects: project costs, timing, personnel, documentation, professional ethics and resource management. This course is required for the dual degree M.Arch./Master of Science in Management program. It may be used as an elective in the M.Arch. program.

ARCH 660. Direct Study In Arch II. 3 credits, 3 contact hours.

ARCH 661. Directed Studies of Architecture. 3 credits, 3 contact hours.
Restriction: completion of core, two elective courses, and approval from the graduate advisor. Independent, in-depth research on an analytical, theoretical or technical area of architecture. Student prepares formal research proposal with permission of faculty advisor and approval of graduate advisor. Required as pre-thesis research. See also course description for MARC 701.

ARCH 662. Special Topics in Architecture. 3 credits, 3 contact hours.
Topics vary each semester. Refer to the School of Architecture bulletin during university registration periods for a list of current topics and possible prerequisites.

ARCH 663. Introduction to Sustainable Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Environment design of buildings. The five characteristics of green buildings: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. The US Green Building Council's Green Building Rating System, review of several major buildings of exemplary design.

ARCH 664. Indoor Environmental Quality in Sustainable Design Buildings. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Supportive ambient conditions, including thermal comfort and acceptable indoor air quality, visual comfort, and appropriate acoustical quality, overall physical and psychological well-being for workplace quality, performance and productivity.

ARCH 665. Sustainable Design of Energy Efficient Buildings. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Evaluation of heating and cooling loads, impact on fuel consumption, energy software analysis for design and efficiency. Technology of passive solar design and building integrated photovoltaics.

ARCH 666. Sustainable Design with Efficient Materials and Resources. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Environmentally sensitive site design; issues of wildlife habitat, erosion, ground water recharge, and threats to water quality of surface water bodies and aquifers. Water reclamation, materials and energy conservation, waste reduction and recycling.

ARCH 672. Architecture and Social Change. 3 credits, 3 contact hours.
Prerequisite: graduate level standing. Analysis of architectural form with respect to political, economic and technological change. The built environment is studied in relation to society and culture. The role of design professions in initiating or supporting change is also considered.

ARCH 675. Elements of Infrastructure Planning. 3 credits, 3 contact hours.
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. Same as MIP 675.

ARCH 676. Architecture of Utopia. 3 credits, 3 contact hours.
Restriction: graduate level standing. Seminar looks at several ideas of utopia from literature and philosophy and how they embody transformations in the structure of space, and their architectural implications.

ARCH 678. Graduate Problems in Modern Housing. 3 credits, 3 contact hours.
Restriction: graduate level standing. Students learn to analyze political, technical and economic aspects of contemporary housing policy and practice. Attempts to provide well-designed, affordable housing responsive to the needs of large numbers of people are examined. Examples of housing from the mid-19th century to the present day are outlined.

ARCH 679. Envisioning Newark. 3 credits, 3 contact hours.
This seminar combines classroom discussion based on historical, analytical and literary texts; field visits to Newark's districts and neighborhoods; and meetings with leaders in government, business, art, education, and community-based organizations. The objective is to introduce students to the redevelopment process underway in Newark, and to use the city as a springboard for a broader investigation of the theory and practice of urban development.

ARCH 680. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: completion of core sequence, permission from graduate advisor and Division of Career Development Services. Students gain work experience and reinforcement of their academic programs. An architecture faculty Co-op advisor monitors and evaluates student work and project. Co-op work experiences may be acceptable equivalents for apprenticeships mandated by the New Jersey State Board of Architects and for eligibility to take the architecture licensing examination. This course is required for participation in the Housing Scholars Program. Course does not fulfill degree requirements.

ARCH 681. Co-Op Work Experience II. 1 credit, 1 contact hour.
Restriction: completion of core sequence, permission of graduate advisor and Division of Career Development Services. Used for extended summer-fall (681) or spring-summer (682) work experience. Does not fulfill degree requirements.

ARCH 682. Co-Op Work Experience III. 0 credits, 0 contact hours.
Restriction: completion of core sequence, permission of graduate advisor and Division of Career Development Services. Used for extended summer-fall (681) or spring-summer (682) work experience. Does not fulfill degree requirements.

ARCH 683. Graduate Coop Work Exper IV. 0 credits, 3 contact hours.

ARCH 686. Research Methods for Environmental Design. 3 credits, 3 contact hours.
Introduction to methods of inquiry useful to professionals planning and designing buildings, communities and cities. Skills developed in problem definition and phenomena: measurement, modeling, testing and evaluation. Open to undergraduates with permission of instructor.

ARCH 701B. Master's Thesis. 3.5 credits, 3.5 contact hours.

ARCH 701C. Masters Thesis. 6 credits, 0 contact hours.

ARCH 770. Development of the American City. 3 credits, 3 contact hours.
Restriction: Enrollment in the Urban Systems PhD program or permission of the instructor.Introduction to research in urban history, focusing on the American city. Key texts that deal with the development of the American city will be studied in depth, with particular emphasis on the approaches, methodologies, and sources. Each student will conduct bibliographic research on a city or urban sector from a defined perspective.

ARCH 771. Pathology of Urban Systems. 3 credits, 3 contact hours.
Restriction: Enrollment in the Urban System PhD program or permission of the instructor. Definition of pathology of urban systems as large-scale disasters that have resulted in major destruction of the urban fabric and called for radical re-planning projects. Investigation of historic case studies. The aftermath of natural and man-made disasters including war; contemporary case studies.

MARC 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: Arch 506G, Arch 661, and approval from graduate advisor. Alternative to Arch 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during Arch 661.

MARC 701A. Master'S Thesis. 1.5 credit, 3 contact hours.
Prerequisites: ARCH 506G, ARCH 661, and approval from graduate advisor. Alternative to ARCH 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during ARCH 661.

MARC 701B. Master's Thesis. 3 credits, 3 contact hours.
Prerequisites: ARCH 506G, ARCH 661, and approval from graduate advisor. Alternative to ARCH 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during ARCH 661.

MARC 701C. Master'S Thesis. 6 credits, 3 contact hours.
Prerequisites: ARCH 506G, ARCH 661, and approval from graduate advisor. Alternative to ARCH 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during ARCH 661.

MIP 601. Interdisciplinary Infrastructure Studio I. 6 credits, 13 contact hours.
Collaborative work on realistic infrastructure projects by teams of students with different professional backgrounds under the supervision of interdisciplinary faculty. A project manager coordinates and ensures that working conditions in practice are simulated in the studio. Projects include analytical, financial and design components and emphasize planning strategies and the coordinating function of the design process. Studio products are presented orally in reviews and documented in written and illustrated reports.

MIP 602. Interdisciplinary Infrastructure Studio II. 6 credits, 13 contact hours.
A comprehensive planning and design project emphasizing infrastructure technologies and information management. CAD and other computer applications are used to produce computer-generated graphics and multi-media presentations. Although subjects and approaches will vary, the work of the studio is intended to develop the students' ability to deal with all facets of infrastructure planning regardless of previous academic background. The final products must include a full written and illustrated report on the project and the research on which it is based.

MIP 612. Introduction to Environmental Policy Studies. 3 credits, 3 contact hours.
Introduction to six areas essential to a comprehensive understanding of environmental policy: concepts of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA, etc.); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio, etc.); industrial perspective (pollution prevention/life cycle engineering, privatization, etc.); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline, etc.). Same as EPS 612.

MIP 618. Public and Private Financing of Urban Areas. 3 credits, 3 contact hours.
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. Same as Fin 618 and Tran 604.

MIP 631. History and Theory of Infrastructure. 3 credits, 3 contact hours.
The historical role of infrastructure in the formation of cities and the relation of planning theories to urban culture. Case studies are used to develop effective ways of learning urban design; method and substance are equally emphasized. Concentration on the social, economic, political, technological and topographic factors that affect urban form; analysis of urban design schemata and their relation to patterns of use; and the critical appraisal of planning ideologies and strategies. Same as ARCH 631H.

MIP 652. Geographic Information Systems. 3 credits, 3 contact hours.
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces this emerging technology and its applications. Same as CE 602 and Tran 602.

MIP 655. Land Use Planning. 3 credits, 3 contact hours.
Spatial relations of human behavior patterns to land use: methods of employment and population studies are evaluated; location and spatial requirements are related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. Same as TRAN 655 and CE 655.

MIP 673. Infrastructure Planning in Practice. 3 credits, 3 contact hours.
Infrastructure planning principles, methods and tools. Through selected examples, acquaintance with infrastructure planning theories and models, quantitative methods of research and analysis, information management, decision making, and implementation techniques. Same as ARCH 673.

MIP 674. Infrastructure and Architecture. 3 credits, 3 contact hours.
Examination of areas of overlap and continuity between architecture, landscape architecture, urban design, building science and infrastructure. Topics include the typology, programming and design of public facilities; the housing fabric; the relation between built form, urban space and infrastructure. Same as ARCH 674.

MIP 675. Elements of Infrastructure Planning. 3 credits, 3 contact hours.
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. Same as ARCH 675.

USYS 702. Evolution American Metropolis. 3 credits, 3 contact hours.
Prerequisites: Doctoral standing, or graduate standing and permission of instructor. This course introduces the morphological and cultural evolution of the global metropolis, from historical and economic, political, geographic, and contemporary perspectives. The emphasis is on the intersection of social and environmental conditions that gave rise to distinct urban areas that have influenced urban populations throughout history. A chronological overview of the settlement, growth, decline and revitalization of global cities is combined with detailed case studies.

USYS 711. The Good City:Env Des& Qual. 3 credits, 3 contact hours.
Prerequisites: Enrolment in Urban Systems Program or by permission of instructor. This course introduces urban systems doctoral students to the various ways in which architects, urban designers, and planners have sought and continue to seek to improve the quality of everyday life in urban and suburban environments through the design of the built environment, both at the scale of neighborhoods and communities and at the scale of buildings. The emphasis is on manipulation of built form, transportation, and public space as responses to perceived problems. Key topic area are housing and neighborhoods, public space, transportation, schools, and hospitals.

USYS 721. Aspects of Urban Form. 3 credits, 3 contact hours.
Prerequisites: Enrollment in Urban Systems PhD Program or by permission of instructor. This seminar course investigates formal aspects of cities, ranging from streets to squares, parks, monuments, residential fabrics, infrastructure, and the overall image. The case studies are draw from historic and contemporary cities and cover a wide geographical area. The inclusion of ?Western? and ?non-Western? examples allows for a cross-cultural perspective. While the physicality of urban elements constitutes the starting point, they will be examined in reference to the political, social cultural, and economic issues and situated in their historic contexts.

USYS 725. Independent Study I. 3 credits, 3 contact hours.
Prerequisites: Permission of Track Director. This designation covers courses for Urban Systems students prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Student may not register for this course more than once with the same supervising faculty member.

USYS 726. Independent Study II. 3 credits, 3 contact hours.
Prerequisites: Permission of Track Director. This designation covers courses for Urban Systems students prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Student may not register for this course more than once with the same supervising faculty member.

USYS 788. Special Topics in Urban Systems. 3 credits, 3 contact hours.
Special-area given when suitable interest develops. Advance notice of forthcoming topics in Urban Systems will be given.

USYS 790. Dissertation Research. 0 credits, 0 contact hours.

USYS 790A. Dissertation Research. 1 credit, 1 contact hour.

USYS 790B. Dissertation Research. 3 credits, 3 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester until a written dissertation is approved.

USYS 790C. Dissertation Research. 6 credits, 6 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

USYS 790D. Dissertation Research. 9 credits, 9 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

USYS 790E. Dissertation Research. 12 credits, 12 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

USYS 792. Dissertation Research. 3 credits, 3 contact hours.
Prerequisites: Permission of Track Director. For students admitted to the Doctor of Philosophy Program in Urban Systems who have not yet passed the qualifying examination. Research is carried out under the supervision of designed Urban Systems faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied to the 24 credits required under USYS 790.

Architecture

Graduate architectural education exposes students to the broad intellectual inquiry of the academy and the specific technical knowledge required in the world of professional practice. Sustainable design is a basic attitude which informs our entire curriculum. Communication skills move from basic visual literacy to instruction in the principles and techniques of digital design: computer-aided design (CAD), computer-aided manufacturing (CAM), three-dimensional digital rendering, and digital animation. Students gain experience through individual design studio projects that range from the small-scale design and manufacture of a single object to a large-scale design of communities.

Our location-five minutes from Newark Penn Station by subway, and thirty minutes from Midtown Manhattan-gives students access to a faculty drawn from the largest concentration of design professionals in the country, and enables those faculty to treat design as a diverse series of real projects on real sites in a vital metropolitan region. In combination with the unparalleled internship opportunities available in New York and Northern New Jersey and the availability of dual degree programs, this approach allows students to both prepare for a career in architecture and to find a direction within the field. The architect envisions and imagines both what is possible, and what ought to be. As a process, design gives form to society and the economic and technological aspects of environmental order.

For students in the Professional M.Arch. Program, partnerships through dual degree tracks in infrastructure planning, management and civil engineering can broaden a general education in architecture. Post-professional opportunities for specialized career directions, scholarly inquiry and research are also offered through degree programs in architectural studies and infrastructure planning.

The faculty comprises practitioners and scholars whose expertise and professional reputation are based on both breadth and depth of achievement. Their work directly engages the architectural discourse through research, publication, public lectures, symposia and professional practice. Many members have received scholarly recognition and design awards.

The New Jersey School of Architecture offers the only publicly supported professional program in New Jersey and is committed to NJIT's reputation as a nationally recognized technological university.

To become registered as a licensed architect in the State of New Jersey, you must earn a degree accredited by the National Architectural Accrediting Board (NAAB). NJIT's M.Arch. degree program is one of only two NAAB-accredited degree programs in the State of New Jersey.

The following statement is taken from the current edition of NAAB's *Conditions and Procedures for Professional Degree Programs in Architecture*: "In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes three types of degrees: the Bachelor of Architecture, the Master of Architecture and the Doctor of Architecture. A program may be granted a 6-year, 3-year, or 2-year term of accreditation, depending on its degree of conformance with established educational standards.

Master's degree programs may consist of a pre-professional undergraduate degree and a professional graduate degree, which when earned sequentially, constitute an accredited professional education. However, the pre-professional degree is not, by itself, recognized as an accredited degree."

The NJIT Master of Architecture (M.Arch.) is a professional degree fully accredited by the NAAB.

Master of Architecture (M.Arch.)

There are two degree options in the M.Arch. program: professional M.Arch. and post-professional M.Arch.

Professional M.Arch.: For students with undergraduate or graduate degrees who do not have previous architectural design courses or experience; the full-time program of study comprises six semesters and meets the education requirements for the Architecture Registration Examination (ARE). It is also appropriate for students who have undergraduate degrees in architecture or related fields, those who have a non-NAAB accredited architecture degree, and all international students who would enter the program with advanced placement. Advanced placement, which reduces the 102-credit degree requirement, is determined at the time of admission through an evaluation of previous academic work.

Post-professional M.Arch.: For students who have an NAAB-accredited professional Bachelor of Architecture (B.Arch.) or an equivalent international degree. International students who intend to pursue professional licensure in the U.S. should apply to the Professional M.Arch Program.

Dual Degree M.Arch. and Master of Infrastructure Planning (M.I.P.): Open only to students in the M.Arch. program options studio sequence, the dual degree program permits students to earn credits towards both M.Arch and M.I.P degrees simultaneously and obtain an M.I.P. in substantially less time than if taken separately. Also see the program description under **Infrastructure Planning** in this catalog.

Dual Degree M.Arch. and M.S. in Management: Open only to students in the M.Arch. program studio options sequence, the dual degree program permits students to obtain an M.S. in Management in substantially less time. Also see the program description under **Management** in this catalog.

Dual Degree M.Arch. and M.S. in Civil Engineering: Open only to students in the M.Arch. program studio options sequence. The dual degree program permits students to obtain an M.S. in Civil Engineering in substantially less time. Also see the program description under **Civil Engineering** in this catalog.

Admission Requirements for all M.Arch. Programs

In addition to completing the application required by NJIT's Office of University Admissions, M.Arch. applicants must also submit School of Architecture supplementary materials forms. To ensure prompt consideration, students should request the forms when they apply for admission to the university.

Applicants are expected to have a minimum undergraduate GPA of 3.0. GRE (general test) scores are required. Applicants to the M.Arch./M.S. in Management degree option may submit GRE scores in lieu of the GMAT scores which are normally required for admission to the M.S. in Management program. Exclusive of the GMAT/GRE requirements, dual degree applicants must satisfy admission requirements for both the School of Architecture and the School of Management.

Admission to the M.Arch. program is based on the applicant's personal statement, letters of recommendation, design portfolio, and previous academic and work experience. Applicants should have completed a minimum of one semester each of college-level physics and calculus; students who lack such a background will be expected to take equivalent course work before entering the second year of the M.Arch. program. Applicants from non-architectural backgrounds are strongly advised that coursework in design, drawing, and/or studio art is useful preparation for graduate study in architecture, and helpful in the process of generating work for inclusion in the portfolio required as an element in all applications. International students with professional degrees in architecture are required to have transcripts evaluated by Educational Credential Evaluators (information is included with School of Architecture supplementary materials). Aggregate TOEFL scores of 80 or higher are required for all international students.

Graduate Certificate Programs: A 12-credit graduate certificate in Sustainable Architecture is available as a step toward either the Post-Professional M.Arch. or the MSArch degree. Students in the Professional M.Arch. Program may use some or all of the courses in this certificate program to satisfy upper-level architecture and free electives. See **Graduate Certificates** in this catalog for further information. For more information on continuing and distance education, contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; email: cpe@njit.edu.

Master of Science in Architecture (MSARCH)

A non-professional, non-design degree program for careers in architectural research and scholarship. Studies often involve interdisciplinary course work.

Admission Requirements

Applicants are expected to have either an NAAB-accredited B.Arch., or a bachelor's degree in architecture or disciplines related to production, operation or use of buildings.

In addition to completing the application required by NJIT's Office of University Admissions, M.S.ARCH applicants must also submit School of Architecture supplementary materials forms. To ensure prompt consideration, students should request the forms when they apply for admission to the university.

Applicants are expected to have a minimum undergraduate GPA of 3.0. GRE (general test) scores are required.

Through interdisciplinary teaching, research and practice made possible by NJIT's resources in architecture, civil and environmental engineering, transportation, management, and environmental policy studies, the program addresses the global need to train planning and design professionals capable of acting across the spectrum of disciplines involved in infrastructure development.

Infrastructure is defined as the whole built fabric of public spaces, institutions, facilities and services that shapes and sustains daily life. Collaboration between the disciplines concerned with different infrastructure components is necessary to develop holistic strategies for building more livable and efficient urban environments. The goal of the M.I.P. program is to gain a coherent understanding of the interrelationships between those components and to develop the potential of integrally planned and designed infrastructure systems to deal more effectively with the critical problems confronting our cities.

Using a variety of project settings, the program focuses on the natural environment and on public space, roads, transportation, services and utilities as interacting physical and spatial systems, as well as on parks, schools, housing and civic institutions. The purpose is to develop operational strategies that integrate the broadest possible range of planning and design policies, methods and actions for improving human settlements; and to resolve in environmental terms the larger social and political issues that affect the quality of life in our communities.

Capitalizing on NJIT 's multidisciplinary resources and location at the center of the nation's greatest regional concentration of urban infrastructure, the M.I.P. program incorporates applied research and realistic problem solving in its curriculum and also offers internships and research assistantships. M.I.P. faculty, drawn from the university's four academic divisions, is supplemented by eminent infrastructure planning practitioners. Collaborative relationships have been established with complementary academic programs at Rutgers University and with regional, national and international institutions concerned with infrastructure. At NJIT, a number of notable research facilities are engaged in specialized work related to infrastructure planning and design.

Master in Infrastructure Planning

A unique interdisciplinary program in infrastructure planning and design directed at students with previous degrees in architecture, landscape architecture, urban planning or civil engineering.

Dual Degree Programs: Dual M.Arch./M.I.P. or M.S. in Civil Engineering/M.I.P. degree options that reduce the number of credits required to obtain the two degrees separately are available to students with superior academic records who hold bachelor's degrees in architecture or engineering from NJIT or equivalent degrees from other universities; or who are prospective graduates of the professional M.Arch. program at NJIT. See "Architecture" for the M.Arch./M.I.P dual degree program description. See the graduate advisor for the M.S. in Civil Engineering/M.I.P. dual degree program description.

Admission Requirements

Applicants must have a bachelor's or a master's degree in architecture, landscape architecture, urban planning, or engineering. A GPA of at least 3.0 is expected and evidence of potential for graduate study is to be demonstrated by a portfolio, letters of recommendation, GRE scores, and TOEFL scores of 550 (pencil and paper) and 213 (computer-based) in the case of international students.

Bridge Program: Students not sufficiently experienced in design will be required to take an intensive bridge course in design prior to entering the program. This course does not count toward degree credit.

NJIT Faculty

A

Alcala, Jose M., University Lecturer

B

Bales, Ervin, Research Professor

Bess, Mark E., University Lecturer

Brothers, David A., Senior University Lecturer

Burgermaster, Matthew A., Assistant Professor

C

Cays, John M., Associate Dean for Academics, College of Architecture and Design

Celik, Zeynep, Distinguished Professor

D

Dart, James, University Lecturer

Decker, Martina, Assistant Professor

De Sousa Santos, Antonio P., Professor Emeritus

E

Elwell, David H., Associate Professor Emeritus

Esperdy, Gabrielle, Associate Professor

F

Franck, Karen A., Professor

G

Garber, Richard J., Associate Professor

Garcia Figueroa, Julio C., University Lecturer

Gauchat, Urs P., Professor

Goldman, Glenn, Professor

Greenfield, Sanford R., Professor Emeritus

H

Harp, Cleveland J., University Lecturer

Hurtado De Mendoza Wahrolen, Maria A., Associate Professor

K

Krumwiede, Keith A., Associate Professor

L

LeCavalier, Jesse, Assistant Professor

M

Moore, Sandy, Associate Professor

Mostoller, G. Michael, Distinguished Professor

N

Narahara, Taro, Assistant Professor

Navin, Thomas R., University Lecturer

O

Ogorzalek, Thomas, University Lecturer

P

Papademetriou, Peter C., Professor Emeritus

R

Russo, John Rhett, Associate Professor

S

Schuman, Anthony W., Associate Professor

Siegel, Joy W., University Lecturer

Sollohub, Darius T., Associate Professor

T

Taher, Rima, Senior University Lecturer

Theodore, Georgeen, Associate Professor

W

Wall, Donald R., Associate Professor Emeritus

Weisman, Leslie K., Professor Emeritus

Wendell, Augustus E., University Lecturer

West, Troy, Associate Professor Emeritus

Wood, Timothy Daniel, University Lecturer

Z

Zarzycki, Andrzej, Associate Professor

Zdepski, Michael, S., Associate Professor

Programs

- Architecture - M.Arch. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march/)
- Architecture - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/ms/)
- Infrastructure Planning - M.I.P. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/infrastructure-planning-masters/)

Double Majors (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/special-programs/)

- Architecture (professional, or post-professional) - M.Arch. and Infrastructure Planning - M.I.P. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-mip/)
- Architecture (professional, or post-professional) - M.Arch. and Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-management-ms/)
- Architecture (professional, or post-professional) - M.Arch. and Civil Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-civil-engineering-ms/)

- Urban Systems - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/urban-systems-phd/)

New Jersey School of Architecture Courses

ARCH 500G. Advanced Architectural Graphics. 3 credits, 3 contact hours.
Introductory computer science with applications in computer graphics for architecture. Emphasizes programming methodology using a high-level language as the vehicle to illustrate concepts. Basic concepts of computer systems, software engineering, algorithm design, programming languages, and data abstraction, with applications.

ARCH 501G. Architectural Design I. 6 credits, 12 contact hours.
Prerequisite: graduate level standing. Core Studio. Fundamentals of architectural design. Sequence of projects explore two- and three-dimensional design. Choice of form and aesthetics is related to spatial resolution of function and context. Design as a representational medium is emphasized. Taken concurrently with ARCH 555G.

ARCH 502G. Architectural Design II. 6 credits, 12 contact hours.
Prerequisites: ARCH 501G, ARCH 528G, ARCH 541G, ARCH 555G. Core Studio. Extends the knowledge of design, basic concepts and ideas introduced in ARCH 501G. Emphasis is on developing technical drawing, and model-making skills. Also covered are two- and three-dimensional composition. Links to the history and theory sequence are made.

ARCH 503G. Architectural Design III. 6 credits, 12 contact hours.
Prerequisites: ARCH 500G, ARCH 502G, ARCH 529G, ARCH 543G, and ARCH 545G. Core Studio, Intermediate design studio. Introduction to structure. Properties of materials both physical and in the abstract. Builds on knowledge gained from construction and structures courses, spatial demands and design possibilities of different structural systems. Design of structure type, model and context, and comparisons of building typology for rational structure. Drawing and its role in design thinking.

ARCH 504G. Architectural Design IV. 6 credits, 12 contact hours.
Prerequisites: ARCH 503G, ARCH 542G, ARCH 544G. ARCH 548G. Corequisite:547G. Second semester intermediate design studio. Design of buildings and integration of systems, physical and conceptual. Design methodology generates new information on buildings as coherent assemblies of systems. Also covers analysis and synthesis of form and introduction to applications of computer-assisted design (CAD). Preparation of design portfolio will complete core studio sequence.

ARCH 505G. Advanced Design Options I. 6 credits, 12 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 506. Advanced Design Options II. 5 credits, 13 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 506G. Advanced Design Options II. 6 credits, 12 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 507G. Advanced Design Options III. 6 credits, 13 contact hours.
Prerequisite: ARCH 504G. Required vertical studio electives; must be taken sequentially. Covers arange of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

ARCH 510. Co-op Work Experience III. 0 credits, 3 contact hours.
Restriction: Approval of the school and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Students are required to complete and present miterm and final projects and/or reports. A designated faculty member monitors and evaluates the student's work and project.

ARCH 513G. Structures III. 3 credits, 3 contact hours.
Prerequisite: ARCH 512G. Review of methods and procedures for choosing structural systems. Overview of differences among wood, steel and concrete systems. Students are introduced to complex structural behavior, prestressed concrete and new structural technology.

ARCH 527G. Situating Prac:Thrshds of Arch. 3 credits, 3 contact hours.
Restriction: Enrolment in Masters of Architecture Program or by permission of instructor. Western architectural theory dating from Vitruvius to the present time. Examines critical texts and studies related building and projects.

ARCH 528G. History of Architecture I. 3 credits, 3 contact hours.
Restriction: graduate level standing. Introduction to the history of architecture. Emphasis on classical architecture from antiquity to the modern period. Evolution of the various themes and theories that underlie western architecture is presented chronologically.

ARCH 529G. History of Architecture II. 3 credits, 3 contact hours.
Prerequisite: ARCH 528G. Continuation of ARCH 528G. Introduces concepts of modernism and brings the history of western architecture to the contemporary period.

ARCH 530. Methodologies of Architectural History, Theory and Criticism. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. A seminar examining the salient methodologies of architectural history, theory and criticism. Structured around a series of critical texts, with each set of core readings intended to provide a basis for analyzing and assessing the approach in question.

ARCH 531A. History of Renaissance Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An examination of the development of Renaissance architecture and urban design in Italy and elsewhere in Europe. The re-emergence of the classical tradition is considered within the context of social, political and economic developments as well as formal intentions.

ARCH 531B. History of Baroque Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An investigation of architectural development from the 17th and 18th centuries in Europe and Latin America, including consideration of stylistic variations, social and political factors, and trends in garden and urban design.

ARCH 531C. History of Modern Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. A study of major tendencies of architectural theory and practice from the mid-19th to the mid-20th centuries. Formal and stylistic transformation is considered in relation to theoretical intentions as well as social, cultural, and technical developments.

ARCH 531D. History of American Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An investigation of the guiding ideals and dominant stylistic trends in American architecture and planning from colonial times to the mid-20th century. Critical shifts in conception and scope of architectural production considered in relation to the prevailing cultural, socio-economic, and technical contexts out of which they evolved.

ARCH 531E. History of Non-Western Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An examination of major architectural traditions of China, Japan, Southeastern Asia, India, and the Middle East. Each area is considered with reference to a conceptual, iconographic and stylistic paradigm that evolved from a particular historical context.

ARCH 531F. Thresholds of Architectural Theory. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. A seminar that investigates key thresholds of Western architectural theory, from Vitruvius to Robert Venturi, with emphasis on examining the corresponding critical theoretical texts and related didactic buildings and projects.

ARCH 531H. Aspects of Urban Form. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. An examination of the major forms and patterns of urban development from classical antiquity to the 20th century, considered in relation to the changing conceptions of the city as well as cultural, socio-economic, and political development.

ARCH 533. Case Studies in Architectural Creativity. 3 credits, 3 contact hours.
Prerequisite: ARCH 364. Considers creativity in architecture from psychological, philosophical and autobiographical perspectives. The buildings, writings and lives of contemporary architects are discussed in the context of general theories of creativity. Each student chooses an individual architect noted for creative accomplishments and prepares a case study of his or her life.

ARCH 534. History of Architectural Technology. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. Survey of the development of building methods and materials. Impact of structural and environmental technology on architectural form and the design process. The role of technology in contemporary architectural theory and practice, including the modern movement, is emphasized.

ARCH 535. History of Architectural Ideas. 3 credits, 3 contact hours.
Prerequisite: ARCH 382. Discusses seminal architectural ideas in the western world from Vitruvius to the present day. Read books written by leading architectural theorists and analyze them in detail.

ARCH 536. Landscape and American Culture. 3 credits, 3 contact hours.
As in architecture, the parallel discipline of landscape architecture involves artistic intention set in conjunction with utilitarian concerns. As such, designs on the land include the integration of the arts and sciences of human culture with nature. Discusses landscape as a manifestation of American culture.

ARCH 537. Advanced Structures. 3 credits, 3 contact hours.
Covers advanced material in structures related to steel and wood design including: steel industrial buildings, rigid frames and earthquake design, wood structures under axial loads, and combined bending and axial loads.

ARCH 538. Sustainable Architecture. 3 credits, 3 contact hours.
Follows two precepts: accepting responsibility for the consequences of design decisions upon human well-being, and the long-term viability of natural systems. Topics include sustainable site design and development, environmentally sensitive building materials, lifecycle cost benefit analysis of building systems, and adaptive reuse.

ARCH 540. Acoustics. 3 credits, 3 contact hours.
Prerequisite: ARCH 327. Architectural acoustics: how we hear, physics of sound and materials, aesthetics of design and the processes of construction. Audible sounds, their interaction, perception of echo and directional hearing are applied to interior and exterior building transmission, room acoustics, and setting acceptable acoustical environments.

ARCH 541. Material Systems in Design. 3 credits, 4 contact hours.
Prerequisite:4th year undergraduate standing or approval from instructor This seminar will allow students to exam material systems that give design agency to matter as a creative and technical force in the making of architecture. In doing so, it will provide students an opportunity to understand and explore the role material matters play in comtemporary architectural theory and praxis. focused on the exploration and understanding og material systems, this course will provide students with the intellectual underpinnings for the re-conceptionalization of matter within thier own design processes.

ARCH 541G. Construction I. 3 credits, 3 contact hours.
This course is an introductory survey of the general principles and application of Sustainable Design, Site Systems, Structural Systems, Environmental Systems, Envelope Systems, Materials and Assembly Systems. This course will primarily focus on low-rise wood and steel structures.

ARCH 542G. Construction II. 3 credits, 3 contact hours.
Prerequisite: ARCH 541G This course is an introductory survey of the interrelationship of the principles and applications of Sustainable Design, Site Design, Structural Systems, Environmental Systems, Envelope Systems and Materials and Assembly Systems. This course will primarily focus on low and medium-rise concrete and masonry structures and is coordinated with a studio design/build experience.

ARCH 543. Lighting. 3 credits, 3 contact hours.
Prerequisites: ARCH 327 or INT 222. Explores, through modeling and calculation, the means by which architectural form and detail influence the luminous environment. Perceptual responses such as visual comfort and delight are examined. Topics include daylighting footprints, model design and testing, and computer-assisted light level analysis. Areas of investigation include the relationship between daylight and electric light in architecture; the variations of light with time; analysis of seasonal and weather differences; role of task in lighting strategies; and means of control for light quantity and quality.

ARCH 543G. Environmental Control Systems I. 3 credits, 3 contact hours.
An introductory survey of the basic principles of building, environmental control, and service systems as these relate to the building envelope. This course will primarily cover thermal enclosure, climate modification, environmental systems, energy use, and sustainable design. It also introduces the principles of health and safety in the design of buildings.

ARCH 544G. Environmental Control Systems II. 3 credits, 3 contact hours.
This is an intermediate course focusing on the understanding of the principles, performance criteria, and applications of environmental and building service systems including lighting, acoustical, plumbing, electrical, vertical transportations, egress, communication, security, and fire protection systems.

ARCH 545. Case Studies in Architectural Technology. 3 credits, 3 contact hours.
Prerequisite: senior standing. Technological systems involved in the construction and use of buildings. Students conduct in-depth investigation of technology-related problems in architecture and construction. Case study method is used. Construction documents and reports are analyzed. Field visits are required.

ARCH 545G. Structures I. 3 credits, 3 contact hours.
This is an intermediate course focusing on the principles of structural behavior in withstanding gravity and lateral forces and on the evolution, range, and appropriate application of structural systems and the criteria for selecting various structural systems in contemporary architecture. Specific architectural procedents from the 20th century are used as validating examples.

ARCH 546. Designing and Optimizing the Building Enclosure. 3 credits, 3 contact hours.
Prerequisite: Any 100 level CS course except CS 100. Considers the building envelope, the boundary dividing the inside of a structure from the outside environment. Study and design optimal enclosures considering energy exchange, the relationship between energy and light, and life cycle costs.

ARCH 546G. Structures: High Rise and Special Applications. 3 credits, 3 contact hours.
Prerequisite: 545G. This is an advanced course focusing on the integration of all building systems including new materials and methods as they relate to high-rise structures and other specialty building types.

ARCH 547. Special Topics in Computer Applications. 3 credits, 3 contact hours.
Prerequisite: senior standing. Evaluation, utilization, and development of computer programs for analysis, simulation and information management. Programs range from energy analysis, building structures analysis, and mechanical systems design to spatial allocation, graphics and computer-aided design. Different theories of information transformation and delivery used in terms of architectural applications. Course hardware ranges from computer-aided design and drafting systems, through micro and mini, to mainframe computers.

ARCH 547G. 4D Integration. 3 credits, 3 contact hours.
Prerequisites: ARCH 542G, ARCH 544G, ARCH 548G. Co-requisite: ARCH 504G. This is a required, advanced design course that uses in-depth, detailed case studies of various construction types, from small scale to large, from simple to complex, to illustrate the totality of building systems integration. In conjunction with site visits, coursework will employ software to examine construction sequences, building components and shop drawings and their relationship to the design processes.

ARCH 548G. Structures II. 3 credits, 3 contact hours.
Prerequisite: ARCG 545G. This is an advanced course dealing with structural computation that will conclude with rigorous case study investigation of hybrid and complex structural systems.

ARCH 549. Life Safety Issues in Contemporary Buildings. 3 credits, 3 contact hours.
Prerequisites: ARCH 327 or INT 222. A variety of life safety and comfort situations studied in terms of specific building types. Topics include building evacuation, compartmentalization, fire fighting and suppression, evaluation and testing of new building materials and systems, systems control and management. Special emphasis is on such building types as multi-use, high-density, schools, hospitals, and other institutional categories.

ARCH 552. Real Estate Analysis for Architects. 3 credits, 3 contact hours.
Introduction to the economic, financial and political aspects of real estate and their effect on architectural decision-making. Topics include needs assessment, real estate appraisal, financial instruments, regulations and real estate, design as value-adding, and the effect of tax policies on real estate development.

ARCH 555G. Architectural Graphics. 3 credits, 5 contact hours.
Restriction: graduate level standing. Documentary, descriptive and denotative media are introduced. Also covers methods of representation, delineation and reproduction. Skills are developed in technical drawing, perspective construction, projections, and format design. Taken concurrently with ARCH 501G.

ARCH 556. Systems Approach to Design and Construction. 3 credits, 3 contact hours.
Lectures, case studies and student projects on understanding human aspiration and needs through design. Topics include land, finance, management, technology, and labor.

ARCH 557. Problems in Modern Housing. 3 credits, 3 contact hours.
Prerequisite: ARCH 382 Historical approach places housing in its social, economic, and political context. Attempts to provide decent, affordable and well-designed housing for broad segments of society are examined. Dwelling is examined through analysis of proto-typical design solutions in urban environments.

ARCH 558. Professional Architectural Practice. 3 credits, 3 contact hours.
Prerequisite: ARCH 364. A forum for examination of the structure and practices of the profession of architecture. The formal and informal relationships between architects, and between architects and clients, government officials, and consultants are studied. Basic principles of office management for the small and large architectural firm are introduced.

ARCH 559. Social Issues in Housing. 3 credits, 3 contact hours.
Lecture/seminar explores the historical, economic, social, technological, and political basis for current American housing policy and practice. Examines government, community-based and private sector attempts, both failed and successful, at providing decent, affordable, and well-designed housing for broad segments of society. Student teams analyze and discuss, in a series of classroom debates, the housing and planning implications of controversial social problems from homelessness and racial segregation to caring for the elderly and people with HIV/AIDS with an emphasis on the role of the architect.

ARCH 561. Integrated Studio Seminar. 3 credits, 3 contact hours.
Prerequisite: ARCH 463. Corequisite: ARCH 564. Held in design studio each week, the lab consists of presentations by the instructor on relevant technical, building code, and life safety-issues as well as student exercises applying these principles to their integrated design studio project or to existing buildings.

ARCH 563. Options Studio III. 5 credits, 12 contact hours.
Prerequisites: ARCH 464, ARCH 423, ARCH 327 and ARCH 429. Studio methodology allows students to select from various building programs, the nature of design dealing with technology, environment and the social order.

ARCH 564. Integrated Design Studio. 5 credits, 12 contact hours.
Prerequisite: ARCH 463 Corequisite: ARCH 565 This Studio focuses on the student's ability to produce a comprehensive architectural project based on a building program and site that includes development of programmed spaces demonstrating an understanding of structural and environmental systems, building envelop systems, life-safety provisions, wall sections and building assemblies and the principles of sustainability. Lecture hour coordinates with studio subject matter. Course materials purchase required.

ARCH 565. Comprehensive Studio Lab. 1 credit, 1 contact hour.
Prerequisite: ARCH 464 Corequisite: ARCH 563 or ARCH 564 Held in design studio each week the lab consists of presentations by the instructor on relevant technical and life safety issues and student excercises applying these principles to thier currecnt design studio project or to existing buildings.

ARCH 566. Advanced Architectural Design Studio. 5 credits, 12 contact hours.
Prerequisite: ARCH 564. This is an advanced architectural design studio, post Comprehensive Studio, studying contemporary design theories, design methods and construction technologies. Emphasis is placed upon independent design research as it relates to the broad range of architectural practice. Exploratory and experimental architectural projects are the focus of the course.

ARCH 569G. Building and Development. 3 credits, 3 contact hours.
Familiarization with the larger process of building production, of which architecture is one important part. Focus on the role of the architect in the areas of current building development: an examination of how redefinition or change might improve the process. Lectures deal with all factors of the building process and interviews with the various actors involved in designing, approving, financing and making buildings. Students have various assignments including a major term project.

ARCH 571. Everyday Life in the Public Realm. 3 credits, 3 contact hours.
A significant portion of everyday life takes place in the public realm of streets, sidewalks, parks, transit stations, government buildings, commercial establishments, and cultural institutions. Focuses on recent descriptions and critiques of public space and proposals for change.

ARCH 572. Architecture and Social Change. 3 credits, 3 contact hours.
Architectural form is analyzed in relation to political, economic and technological change, and change in social values. Buildings and other designed environments such as parks, streets and neighborhoods are studied relative to the social processes and institutions that generate and transform them. The role of the design professions in initiating or supporting change also is considered.

ARCH 573. Technologies for Community and Urban Design. 3 credits, 3 contact hours.
Advanced and traditional technologies analyzed with regard to their role in community and city design, construction and reconstruction. Emphasis on technological systems influencing location, configuration and use. Examples are infrastructures, communication systems and construction technologies. Develops skills in using methods to evaluate alternative technologies relative to their social, economic and physical promise, problems and feasibility.

ARCH 574. Case Studies in Community and Urban Design. 3 credits, 3 contact hours.
In-depth investigation of specific real-world problems of urban or community design carried out using case method approach. Current practices in the U.S. and other countries studied using interviews with designers, developers, community groups and government agencies. Site visits, reports and other documents provide important sources of information. Final report with supporting documentation required.

ARCH 576. Architecture of Utopia. 3 credits, 3 contact hours.
Seminar for the review of utopian projects that have attempted to embody and strengthen social ideas through transformations in the structuring of space. Architectural implications of different literary and philosophical utopias analyzed with an emphasis on those experimental proposals which were realized, in whole or in part, in built form.

ARCH 579G. Professional Architectural Practice. 3 credits, 3 contact hours.
Restriction: completion of M.Arch. core sequence. Review of the formal, informal, legal, and ethical obligations of the professional architect. Traditional relationships among the architect, clients, engineers and other participants in the design and building industry are studied. Principles of office management and problems of liability are introduced. Also fulfills core requirement of dual degree option for M.Arch./Master of Science in Management.

ARCH 583. ST:. 3 credits, 3 contact hours.
Group investigation of problem of special interest in architecture.

ARCH 588. Architoons. 3 credits, 3 contact hours.
Prerequisite: ARCH 364. Through the medium of film, applies literary devices to architectural contexts, including caricature, parody, lampoon, satire and farce. Studies historical and contemporary animations and short films for their treatment of meaning, story line and sequence, timing, environmental and psychological mood, atmosphere and emotion. Using 3-D modeling and animation software, each student produces an animated short subject illustrating an architectural principle or providing a humorous look at architectural history and theory.

ARCH 591. Independent Study. 1 credit, 1 contact hour.

ARCH 592. Independent Study. 2 credits, 2 contact hours.

ARCH 593. Independent Study. 3 credits, 3 contact hours.

ARCH 619. Architectural Photography. 3 credits, 3 contact hours.
Prerequisites: ARCH 501G, ARCH 502G, ARCH 503G. Photography for architectural presentations and portfolios. Lectures include orientation on light and space, slide presentations, and the use of text to reinforce photographic material. Demonstrations include basic darkroom techniques, and methods to encourage experimentation in photography.

ARCH 630. Methodology of Architectural History, Theory and Criticism. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. This seminar is structured around notable readings on architectural history, theory and criticism to provide students with a sound basis for critical analysis and assessment. It is recommended for students who select history and theory as their area of concentration.

ARCH 631A. History of Renaissance Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Development of architecture and urban design in Italy and elsewhere in Europe during the Renaissance: re-emergence of the classical Greek and Roman architectural tradition; social, political and economic developments; formal intentions and transformations in the 16th and 17th centuries.

ARCH 631B. History of Baroque Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. The emergence of baroque architecture and urban design in Rome in the 17th century; analysis of the works of Bernini, Borromini, Cortona and their contemporaries and successors through 1750. Development of baroque architecture elsewhere in Italy and Europe; late baroque and rococo; the advent of neo-classicism.

ARCH 631C. History of Modern Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Major tendencies in architectural theory and practice from the mid-19th to the mid-20th centuries. Formal and stylistic transformation considered in relation to theory, social, cultural, and technical developments.

ARCH 631D. History of American Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Aesthetic, social, cultural and technical developments in American architecture and planning, from colonial times to the mid-20th century.

ARCH 631E. History of Non-Western Architecture. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Examination of major architectural traditions and styles of China, Japan, Southeast Asia, India and the Middle East.

ARCH 634. History of Architectural Technology. 3 credits, 3 contact hours.
Prerequisites: ARCH 528G, ARCH 529G. Survey of the development of building methods and materials. Impact of structural and environmental technology on architectural form and the design process. The role of technology in contemporary architectural theory and practice including the modern movement is emphasized. Recommended for students who select building science as their area of concentration.

ARCH 636. Methods of Urban History. 3 credits, 3 contact hours.
Prerequisite: Graduate status The seminar examines methods for conducting historically driven, interdisciplinary research on the built environment (with a focus on cities and suburbs) through the lens of architecture, landscape, geography, and material culture. Methodology is studied to inform the production of urban history and to frame historical perspectives on contemporary urban issues. Historiography and critical theory are key aspects of the study of urban history's methodologies. In addition to traditional historical methodologies, the course examines emerging digital humanities methodologies.

ARCH 637. Teaching Sem:Arch Pedagogies. 3 credits, 3 contact hours.
Prerequisite: Graduate status This course is a graduate seminar that introduces students to key issues in contemporary pedagogy, understood as the art, craft, theory and practice of teaching. The course examines principles and constructs of teaching and education, as well as their pragmatics and practicalities. The main focus of the course is architectural education with discussions informed by diverse issues such as technology and the information revolution and multiculturalism and globalism.

ARCH 640. Acoustics. 3 credits, 3 contact hours.
Restriction: completion of core sequence or equivalent. Architectural acoustics: how we hear, physics of sound and materials, aesthetics of design and the processes of construction. Audible sounds, their interaction, perception of echo and directional hearing are applied to interior and exterior building transmission, room acoustics, and setting acceptable acoustical environments.

ARCH 641. Experiments In Structural Form. 3 credits, 3 contact hours.
Restriction: completion of core sequence or equivalent. Architectural form through model design, construction and testing of minimum structures, including elements of soap film study, orthogonal and diagonal grids, design of tension grids through deflection loading, photoelastic models and calculation. Also compares geometric systems, patterning and proportion, symmetry, asymmetry, relative size, nesting, linearity and spiral orders, rectilinear patterns, and randomness in architectural structure and form.

ARCH 642. Digital Modeling & Fabrication. 3 credits, 3 contact hours.
Prerequisite: ARCH 501G This is a 3-credit seminar course for graduate students exploring advanced 3-dimensional computer modeling techniques and data export for assembly and fabrication to various computer numerically controlled (CNC) hardware available at the School of Architecture. Specifically, students engage in NURBS and solid modeling using Rhinoceros 3D and export data through various Rhino plug-ins including RhinoCAM, which writes G- and M- Codes for 2 and 3D milling operations.

ARCH 643. Lighting. 3 credits, 4 contact hours.
Prerequisites: ARCH 501G and ARCH 502G. Through modeling and calculation, influence of the luminous environment on architectural form and detail. Perceptions of visual comfort and daylight are examined. Topics include daylighting footprints, model design and testing, and computer-assisted, light-level analysis. Relationship between daylight and artificial light in architecture, variations of light with time, analysis of seasonal and weather differences, role of task in lighting strategies, and means of control for light quantity and quality.

ARCH 645. Case Studies in Architectural Technology. 3 credits, 3 contact hours.
Restriction: completion of core sequence. Case-study method used for in-depth investigation of the relationship among various technological systems in a building and technologically-related problems in architecture and construction.

ARCH 646. Designing and Optimizing the Building Enclosure. 3 credits, 3 contact hours.
Restriction: completion of core sequence. Considers the "building envelope," the boundary dividing the inside of a structure from the outside environment. Students study and design optimal enclosures considering energy exchange, the relationship between energy and lighting, and life cycle costs.

ARCH 647. Special Topics in Computer Applications. 3 credits, 5 contact hours.
Restriction: completion of core sequence. Evaluation and use of computer graphics hardware and software for architectural applications. Focus is on computers as tools, operating systems and methods of data manipulation. Two- and three-dimensional modeling software are discussed, and assignments using such software are given to provide understanding of the modeling of built environments.

ARCH 649. Life Safety Issues in Contemporary Buildings. 3 credits, 3 contact hours.
Restriction: completion of core sequence. A variety of life safety and comfort situations are studied in different building types. Topics include building evacuation, compartmentalizing, fire fighting and suppression, evaluation and testing of new building materials and systems, systems control and management. Special attention is placed on multi-use, high-density buildings.

ARCH 650. Economy Of Building. 3 credits, 3 contact hours.
Restriction: completion of core sequence or equivalent. Economic consequences of design decisions. Topics include: relationship among economy, efficiency and quality; life-cycle cost of design; improving the economy of building processes and products through innovation; and environmental concerns. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

ARCH 651. Real Estate Analysis for Architects. 3 credits, 3 contact hours.
Restriction: completion of core sequence. Introduction to the economic, financial and political aspects of real estate and their effect on architectural decision-making. Topics include: needs assessment, real estate appraisal, financial instruments, regulations and real estate, design as value-adding, and the effect of tax policies on real estate development. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

ARCH 652. Architectural Project Management. 3 credits, 3 contact hours.
Prerequisite: ARCH 579G. Restriction: completion of core sequence. Management of architectural projects: project costs, timing, personnel, documentation, professional ethics and resource management. This course is required for the dual degree M.Arch./Master of Science in Management program. It may be used as an elective in the M.Arch. program.

ARCH 660. Direct Study In Arch II. 3 credits, 3 contact hours.

ARCH 661. Directed Studies of Architecture. 3 credits, 3 contact hours.
Restriction: completion of core, two elective courses, and approval from the graduate advisor. Independent, in-depth research on an analytical, theoretical or technical area of architecture. Student prepares formal research proposal with permission of faculty advisor and approval of graduate advisor. Required as pre-thesis research. See also course description for MARC 701.

ARCH 662. Special Topics in Architecture. 3 credits, 3 contact hours.
Topics vary each semester. Refer to the School of Architecture bulletin during university registration periods for a list of current topics and possible prerequisites.

ARCH 663. Introduction to Sustainable Architecture. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Environment design of buildings. The five characteristics of green buildings: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. The US Green Building Council's Green Building Rating System, review of several major buildings of exemplary design.

ARCH 664. Indoor Environmental Quality in Sustainable Design Buildings. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Supportive ambient conditions, including thermal comfort and acceptable indoor air quality, visual comfort, and appropriate acoustical quality, overall physical and psychological well-being for workplace quality, performance and productivity.

ARCH 665. Sustainable Design of Energy Efficient Buildings. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Evaluation of heating and cooling loads, impact on fuel consumption, energy software analysis for design and efficiency. Technology of passive solar design and building integrated photovoltaics.

ARCH 666. Sustainable Design with Efficient Materials and Resources. 3 credits, 3 contact hours.
Prerequisite: ARCH 543G or ARCH 227. Environmentally sensitive site design; issues of wildlife habitat, erosion, ground water recharge, and threats to water quality of surface water bodies and aquifers. Water reclamation, materials and energy conservation, waste reduction and recycling.

ARCH 672. Architecture and Social Change. 3 credits, 3 contact hours.
Prerequisite: graduate level standing. Analysis of architectural form with respect to political, economic and technological change. The built environment is studied in relation to society and culture. The role of design professions in initiating or supporting change is also considered.

ARCH 675. Elements of Infrastructure Planning. 3 credits, 3 contact hours.
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. Same as MIP 675.

ARCH 676. Architecture of Utopia. 3 credits, 3 contact hours.
Restriction: graduate level standing. Seminar looks at several ideas of utopia from literature and philosophy and how they embody transformations in the structure of space, and their architectural implications.

ARCH 678. Graduate Problems in Modern Housing. 3 credits, 3 contact hours.
Restriction: graduate level standing. Students learn to analyze political, technical and economic aspects of contemporary housing policy and practice. Attempts to provide well-designed, affordable housing responsive to the needs of large numbers of people are examined. Examples of housing from the mid-19th century to the present day are outlined.

ARCH 679. Envisioning Newark. 3 credits, 3 contact hours.
This seminar combines classroom discussion based on historical, analytical and literary texts; field visits to Newark's districts and neighborhoods; and meetings with leaders in government, business, art, education, and community-based organizations. The objective is to introduce students to the redevelopment process underway in Newark, and to use the city as a springboard for a broader investigation of the theory and practice of urban development.

ARCH 680. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: completion of core sequence, permission from graduate advisor and Division of Career Development Services. Students gain work experience and reinforcement of their academic programs. An architecture faculty Co-op advisor monitors and evaluates student work and project. Co-op work experiences may be acceptable equivalents for apprenticeships mandated by the New Jersey State Board of Architects and for eligibility to take the architecture licensing examination. This course is required for participation in the Housing Scholars Program. Course does not fulfill degree requirements.

ARCH 681. Co-Op Work Experience II. 1 credit, 1 contact hour.
Restriction: completion of core sequence, permission of graduate advisor and Division of Career Development Services. Used for extended summer-fall (681) or spring-summer (682) work experience. Does not fulfill degree requirements.

ARCH 682. Co-Op Work Experience III. 0 credits, 0 contact hours.
Restriction: completion of core sequence, permission of graduate advisor and Division of Career Development Services. Used for extended summer-fall (681) or spring-summer (682) work experience. Does not fulfill degree requirements.

ARCH 683. Graduate Coop Work Exper IV. 0 credits, 3 contact hours.

ARCH 686. Research Methods for Environmental Design. 3 credits, 3 contact hours.
Introduction to methods of inquiry useful to professionals planning and designing buildings, communities and cities. Skills developed in problem definition and phenomena: measurement, modeling, testing and evaluation. Open to undergraduates with permission of instructor.

ARCH 701B. Master's Thesis. 3.5 credits, 3.5 contact hours.

ARCH 701C. Masters Thesis. 6 credits, 0 contact hours.

ARCH 770. Development of the American City. 3 credits, 3 contact hours.
Restriction: Enrollment in the Urban Systems PhD program or permission of the instructor.Introduction to research in urban history, focusing on the American city. Key texts that deal with the development of the American city will be studied in depth, with particular emphasis on the approaches, methodologies, and sources. Each student will conduct bibliographic research on a city or urban sector from a defined perspective.

ARCH 771. Pathology of Urban Systems. 3 credits, 3 contact hours.
Restriction: Enrollment in the Urban System PhD program or permission of the instructor. Definition of pathology of urban systems as large-scale disasters that have resulted in major destruction of the urban fabric and called for radical re-planning projects. Investigation of historic case studies. The aftermath of natural and man-made disasters including war; contemporary case studies.

MARC 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: Arch 506G, Arch 661, and approval from graduate advisor. Alternative to Arch 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during Arch 661.

MARC 701A. Master'S Thesis. 1.5 credit, 3 contact hours.
Prerequisites: ARCH 506G, ARCH 661, and approval from graduate advisor. Alternative to ARCH 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during ARCH 661.

MARC 701B. Master's Thesis. 3 credits, 3 contact hours.
Prerequisites: ARCH 506G, ARCH 661, and approval from graduate advisor. Alternative to ARCH 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during ARCH 661.

MARC 701C. Master'S Thesis. 6 credits, 3 contact hours.
Prerequisites: ARCH 506G, ARCH 661, and approval from graduate advisor. Alternative to ARCH 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during ARCH 661.

MIP 601. Interdisciplinary Infrastructure Studio I. 6 credits, 13 contact hours.
Collaborative work on realistic infrastructure projects by teams of students with different professional backgrounds under the supervision of interdisciplinary faculty. A project manager coordinates and ensures that working conditions in practice are simulated in the studio. Projects include analytical, financial and design components and emphasize planning strategies and the coordinating function of the design process. Studio products are presented orally in reviews and documented in written and illustrated reports.

MIP 602. Interdisciplinary Infrastructure Studio II. 6 credits, 13 contact hours.
A comprehensive planning and design project emphasizing infrastructure technologies and information management. CAD and other computer applications are used to produce computer-generated graphics and multi-media presentations. Although subjects and approaches will vary, the work of the studio is intended to develop the students' ability to deal with all facets of infrastructure planning regardless of previous academic background. The final products must include a full written and illustrated report on the project and the research on which it is based.

MIP 612. Introduction to Environmental Policy Studies. 3 credits, 3 contact hours.
Introduction to six areas essential to a comprehensive understanding of environmental policy: concepts of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA, etc.); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio, etc.); industrial perspective (pollution prevention/life cycle engineering, privatization, etc.); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline, etc.). Same as EPS 612.

MIP 618. Public and Private Financing of Urban Areas. 3 credits, 3 contact hours.
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. Same as Fin 618 and Tran 604.

MIP 631. History and Theory of Infrastructure. 3 credits, 3 contact hours.
The historical role of infrastructure in the formation of cities and the relation of planning theories to urban culture. Case studies are used to develop effective ways of learning urban design; method and substance are equally emphasized. Concentration on the social, economic, political, technological and topographic factors that affect urban form; analysis of urban design schemata and their relation to patterns of use; and the critical appraisal of planning ideologies and strategies. Same as ARCH 631H.

MIP 652. Geographic Information Systems. 3 credits, 3 contact hours.
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces this emerging technology and its applications. Same as CE 602 and Tran 602.

MIP 655. Land Use Planning. 3 credits, 3 contact hours.
Spatial relations of human behavior patterns to land use: methods of employment and population studies are evaluated; location and spatial requirements are related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. Same as TRAN 655 and CE 655.

MIP 673. Infrastructure Planning in Practice. 3 credits, 3 contact hours.
Infrastructure planning principles, methods and tools. Through selected examples, acquaintance with infrastructure planning theories and models, quantitative methods of research and analysis, information management, decision making, and implementation techniques. Same as ARCH 673.

MIP 674. Infrastructure and Architecture. 3 credits, 3 contact hours.
Examination of areas of overlap and continuity between architecture, landscape architecture, urban design, building science and infrastructure. Topics include the typology, programming and design of public facilities; the housing fabric; the relation between built form, urban space and infrastructure. Same as ARCH 674.

MIP 675. Elements of Infrastructure Planning. 3 credits, 3 contact hours.
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. Same as ARCH 675.

USYS 702. Evolution American Metropolis. 3 credits, 3 contact hours.
Prerequisites: Doctoral standing, or graduate standing and permission of instructor. This course introduces the morphological and cultural evolution of the global metropolis, from historical and economic, political, geographic, and contemporary perspectives. The emphasis is on the intersection of social and environmental conditions that gave rise to distinct urban areas that have influenced urban populations throughout history. A chronological overview of the settlement, growth, decline and revitalization of global cities is combined with detailed case studies.

USYS 711. The Good City:Env Des& Qual. 3 credits, 3 contact hours.
Prerequisites: Enrolment in Urban Systems Program or by permission of instructor. This course introduces urban systems doctoral students to the various ways in which architects, urban designers, and planners have sought and continue to seek to improve the quality of everyday life in urban and suburban environments through the design of the built environment, both at the scale of neighborhoods and communities and at the scale of buildings. The emphasis is on manipulation of built form, transportation, and public space as responses to perceived problems. Key topic area are housing and neighborhoods, public space, transportation, schools, and hospitals.

USYS 721. Aspects of Urban Form. 3 credits, 3 contact hours.
Prerequisites: Enrollment in Urban Systems PhD Program or by permission of instructor. This seminar course investigates formal aspects of cities, ranging from streets to squares, parks, monuments, residential fabrics, infrastructure, and the overall image. The case studies are draw from historic and contemporary cities and cover a wide geographical area. The inclusion of ?Western? and ?non-Western? examples allows for a cross-cultural perspective. While the physicality of urban elements constitutes the starting point, they will be examined in reference to the political, social cultural, and economic issues and situated in their historic contexts.

USYS 725. Independent Study I. 3 credits, 3 contact hours.
Prerequisites: Permission of Track Director. This designation covers courses for Urban Systems students prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Student may not register for this course more than once with the same supervising faculty member.

USYS 726. Independent Study II. 3 credits, 3 contact hours.
Prerequisites: Permission of Track Director. This designation covers courses for Urban Systems students prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Student may not register for this course more than once with the same supervising faculty member.

USYS 788. Special Topics in Urban Systems. 3 credits, 3 contact hours.
Special-area given when suitable interest develops. Advance notice of forthcoming topics in Urban Systems will be given.

USYS 790. Dissertation Research. 0 credits, 0 contact hours.

USYS 790A. Dissertation Research. 1 credit, 1 contact hour.

USYS 790B. Dissertation Research. 3 credits, 3 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester until a written dissertation is approved.

USYS 790C. Dissertation Research. 6 credits, 6 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

USYS 790D. Dissertation Research. 9 credits, 9 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

USYS 790E. Dissertation Research. 12 credits, 12 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 24 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 3 credits of dissertation per semester until 24 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

USYS 792. Dissertation Research. 3 credits, 3 contact hours.
Prerequisites: Permission of Track Director. For students admitted to the Doctor of Philosophy Program in Urban Systems who have not yet passed the qualifying examination. Research is carried out under the supervision of designed Urban Systems faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied to the 24 credits required under USYS 790.

M.S. in Architecture

The program consists of 30 credits of required and elective courses and may be taken either full- or part-time. Students in preparation for further study at the doctoral level may be required to complete an additional 6 credit thesis. Students are required to design their programs in consultation with the graduate advisor and lead faculty member in the area of specialization. Among the available areas of concentration are Sustainable Architecture, Resilient Architecture, Architectural History, Digital Design, and Urban Systems.

To remain in good academic standing, students must maintain a cumulative GPA of 3.0 in graduate courses.

Master of Architecture

Degree Requirements for Professional M.Arch.

This 102-credit program consists of a 72-credit core and an options sequence of 30 credits including 12 studio and 18 elective credits. Students are expected to complete the core sequence in a minimum of two years. Before registering for courses, all students must consult with the graduate advisor to plan an appropriate course of study.

Students must submit a portfolio of design work at completion of the core courses. The portfolio will be reviewed in connection with advising students on their further program of study.

Core courses in the M.Arch. program represent the minimum background necessary to meet NAAB standards. If students demonstrate that they have previously completed equivalent course work, degree credit requirements may be reduced to less than the 102 credits required for the program. To remain in good academic standing, students must maintain a cumulative GPA of 3.0 in graduate courses. Students must repeat any design studio course in which they receive a grade of C. A grade of C+ in any design studio must be followed by a subsequent grade sufficient to raise the annual cumulative design studio GPA to 2.75. Incomplete (I) grades for studio and prerequisite courses must be removed before students will be permitted to register for continuing course work in the program.

Code	Title	Credits
Core Courses		
ARCH 500G	Advanced Architectural Graphics	3
ARCH 501G	Architectural Design I	6
ARCH 502G	Architectural Design II	6
ARCH 503G	Architectural Design III	6
ARCH 504G	Architectural Design IV	6
ARCH 541G	Construction I	3
ARCH 542G	Construction II	3
ARCH 543G	Environmental Control Systems I	3
ARCH 544G	Environmental Control Systems II	3
ARCH 545G	Structures I	3
ARCH 548G	Structures II	3
ARCH 547G	4D Integration	3
ARCH 528G	History of Architecture I	3
ARCH 529G	History of Architecture II	3
ARCH 555G	Architectural Graphics	3
ARCH 569G	Building and Development	3
ARCH 579G	Professional Architectural Practice	3
Two courses in architectural history [1,2]		6
One course in contemporary architectural theory [2]		3
Option Sequence		
Select two of the following:		12
ARCH 505G	Advanced Design Options I	
ARCH 506G	Advanced Design Options II	
ARCH 507G	Advanced Design Options III	
MARC 701	Master'S Thesis	
ARCH XXX	Electives [2]	9
Electives [2]		9
Total Credits		102

1. Including one course in non-western, regional, or vernacular architecture.
2. To be selected in consultation with the graduate advisor.

With the exception of History/Theory Selectives, ARCH 569G Building and Development and ARCH 579G Professional Architectural Practice, all core courses must be completed before proceeding to the options sequence.

Master of Architecture and M.S. in Civil Engineering

This dual degree option is a specific tailoring of the construction engineering and management specialization in the M.S. in Civil Engineering program and is only available to students pursuing the M.Arch. degree.

The dual degree program permits students to obtain both an M.Arch. and a M.S. in Civil Engineering in substantially less time than if each degree was pursued separately. A maximum of 15 credits may be used to satisfy requirements of both degrees.

Students take courses shown below to fulfill requirements for the M.S. in Civil Engineering, or their equivalent. There is no thesis requirement. Students without a bachelor's degree in civil engineering must complete the bridge program; these courses do not count toward degree requirements. **See the undergraduate catalog for descriptions of these courses.**

All bridge courses are required as prerequisites for admission to the MSCE degree. All students in this dual-degree program must take MATH 112 and 105 or equivalent courses. Equivalency for courses taken at other institutions is determined by NCE Graduate Advisor.

Up to 15 credits of graduate-level coursework may be applied to both the M.Arch. and M.S. Students may take additional courses at the graduate level during their undergraduate career, up to a maximum of 21 credits, but no additional graduate courses beyond the first 15 credits can be counted toward the first masters degree requirements.

All prerequisite courses must be completed prior to taking bridge courses. All bridge courses must be completed prior to taking CoAD graduate courses counting toward both degrees. All CoAD graduate courses counting toward both degrees must be taken before taking any NCE graduate courses counting only toward the MSCE. The M.Arch degree must be completed before formal admission to the MSCE. No more than a total of 21 graduate credits toward the second degree (15 counted toward both degrees, 6 counted only to the second graduate degree) may be taken prior to completion of the first graduate degree. The program requires at least one additional semester of full-time study as a graduate student, following completion of the first graduate degree.

At the time of admission to the dual degree program, the civil engineering graduate advisor will determine if any M.S. in Civil Engineering course requirements can be waived.

The requirements to obtain the M.S. in Civil Engineering degree are:

M.Arch. and M.S. in Civil Engineering (civil engineering bachelor's degree)

M.Arch. Requirements

Code	Title	Credits
Core Courses		
ARCH 500G	Advanced Architectural Graphics	3
ARCH 501G	Architectural Design I	6
ARCH 502G	Architectural Design II	6
ARCH 503G	Architectural Design III	6
ARCH 504G	Architectural Design IV	6
ARCH 541G	Construction I	3
ARCH 542G	Construction II	3
ARCH 543G	Environmental Control Systems I	3
ARCH 544G	Environmental Control Systems II	3
ARCH 545G	Structures I	3
ARCH 548G	Structures II	3
ARCH 547G	4D Integration	3
ARCH 528G	History of Architecture I	3
ARCH 529G	History of Architecture II	3
ARCH 555G	Architectural Graphics	3
ARCH 569G	Building and Development	3
ARCH 579G	Professional Architectural Practice	3
Two courses in architectural history [1,2]		6
One course in contemporary architectural theory [2]		3
Option Sequence		
Select two of the following:		12
ARCH 505G	Advanced Design Options I	

ARCH 506G	Advanced Design Options II	
ARCH 507G	Advanced Design Options III	
MARC 701	Master'S Thesis	
ARCH XXX	Electives [2]	9
Electives [2]		9
Total Credits		102

[1] Including one course in non-western, regional, or vernacular architecture.
[2] To be selected in consultation with the graduate advisor.

With the exception of History/Theory Selectives, ARCH 569G Building and Development and ARCH 579G Professional Architectural Practice, all core courses must be completed before proceeding to the options sequence.

M.S. in Civil Engineering Requirements

Code	Title	Credits
Core Courses		
CE 610	Construction Management	3
CE 611	Project Planning and Control	3
CE 616	Construction Cost Estimating	3
EM 632	Legal Aspects in Construction	3
Required Courses		
ARCH 650	Economy Of Building	3
ARCH 652	Architectural Project Management	3
ARCH 675	Elements of Infrastructure Planning	3
MIS 645	Information Systems Principles	3
Electives		
Select two of the following:		6
CE 615	Infrastructure and Facilities Remediation	
CE 631	Advanced Reinforced Concrete Design	
CE 642	Foundation Engineering	
CE 702	Special Topics in Civil Engineering	
CE 711	Methods Improvement in Construction	
ENE 662	Site Remediation	
ENE 671	Environmental Impact Analysis	
Total Credits		30

M.Arch. and M.S. in Civil Engineering (no civil engineering bachelor's degree)

M.Arch. Requirements

Code	Title	Credits
Core Courses		
ARCH 500G	Advanced Architectural Graphics	3
ARCH 501G	Architectural Design I	6
ARCH 502G	Architectural Design II	6
ARCH 503G	Architectural Design III	6
ARCH 504G	Architectural Design IV	6
ARCH 541G	Construction I	3
ARCH 542G	Construction II	3
ARCH 543G	Environmental Control Systems I	3
ARCH 544G	Environmental Control Systems II	3
ARCH 545G	Structures I	3
ARCH 548G	Structures II	3
ARCH 547G	4D Integration	3

ARCH 528G	History of Architecture I	3
ARCH 529G	History of Architecture II	3
ARCH 555G	Architectural Graphics	3
ARCH 569G	Building and Development	3
ARCH 579G	Professional Architectural Practice	3
Two courses in architectural history [1,2]		6
One course in contemporary architectural theory [2]		3
Option Sequence		
Select two of the following:		12
ARCH 505G	Advanced Design Options I	
ARCH 506G	Advanced Design Options II	
ARCH 507G	Advanced Design Options III	
MARC 701	Master'S Thesis	
ARCH XXX	Electives [2]	9
Electives [2]		9
Total Credits		102

1. Including one course in non-western, regional, or vernacular architecture.
2. To be selected in consultation with the graduate advisor.

With the exception of History/Theory Selectives, ARCH 569G Building and Development and ARCH 579G Professional Architectural Practice, all core courses must be completed before proceeding to the options sequence.

M.S. in Civil Engineering Requirements (w/o a BSCE degree)

(30 credits)

Code	Title	Credits
Bridge Courses [1]		
All Bridge Courses Required [*]		
CE 200	Surveying	2
CE 200A	Surveying Laboratory	1
CE 341	Soil Mechanics	3
CE 341A	Soil Mechanics Laboratory	1
MATH 105	Elementary Probability and Statistics	3
MATH 112	Calculus II	4
Total Credits		14

Code	Title	Credits
Courses counted to both Degrees (12 required credits)		**12**
Select four courses		
MIP 631	History and Theory of Infrastructure	
MIP 652	Geographic Information Systems	
MIP 655	Land Use Planning	
MIP 673	Infrastructure Planning in Practice	
MIP 675	Elements of Infrastructure Planning	
ARCH 569G	Building and Development	
ARCH 647	Special Topics in Computer Applications	
ARCH 649	Life Safety Issues in Contemporary Buildings	
ARCH 650	Economy Of Building	
ARCH 651	Real Estate Analysis for Architects	
ARCH 652	Architectural Project Management	
ARCH 663	Introduction to Sustainable Architecture	
ARCH 664	Indoor Environmental Quality in Sustainable Design Buildings	
ARCH 665	Sustainable Design of Energy Efficient Buildings	

ARCH 666	Sustainable Design with Efficient Materials and Resources	
Civil and Environmental Engineering Core Courses (12 required credits)		12
CE 610	Construction Management	
CE 611	Project Planning and Control	
CE 616	Construction Cost Estimating	
EM 632	Legal Aspects in Construction	
Elective Credits in Civil & Environmental Engineering		6
Select two of the following courses		
CE 615	Infrastructure and Facilities Remediation	
CE 617	Historic Preservation	
CE 631	Advanced Reinforced Concrete Design	
CE 642	Foundation Engineering	
Required Courses		
CE 644	Geology in Engineering	
CE 671	Performance and Risk Analysis of Infrastructure Systems	
CE 702	Special Topics in Civil Engineering	
CE 711	Methods Improvement in Construction	
ENE 662	Site Remediation	
ENE 671	Environmental Impact Analysis	
Total Credits		30

[1] Bridge courses are required as prerequisites for admission to the MSCE program

* Prereq courses for CE 341 for M.Arch students are MATH 112 & 105, ARCH 545G & 548G

Co-op Work Experience in Architecture and the **Housing Scholars Program** give students an opportunity to gain additive credits and salaried employment.

To become eligible to take the architecture registration examination in New Jersey, professional M.Arch. Graduates must complete three years of practical work experience apprenticeship that meet specific criteria set by the New Jersey State Board of Architects. Co-op internship work experiences in architecture meeting these criteria are acceptable equivalents for such apprenticeships, and are available to NJIT students. Students become eligible after completing the first year of M.Arch core courses.

The Housing Scholars Program provides college students with paid summer internships at non-profit, community-based affordable housing organizations, and is jointly administered by NJIT's Division of Career Development Services and the New Jersey Department of Community Affairs. Housing Fellows are placed with community-based, non-profit organizations that initiate affordable housing and related projects. Graduate students who have completed at least 28 credits of core courses and who have an overall cumulative GPA of 3.2 or above are eligible to participate. Scholars are selected through a competitive application to the Division of Career Development Services and an interview process throughout February and March, and begin their internship in early June.

Students should consult the School of Architecture co-op advisor for details on work experience and the Housing Scholars program.

Master of Architecture and M.S. in Management

The dual degree option is only available to students pursuing the M.Arch. The dual degree program permits students to obtain both an M.Arch. and a M.S. in Management in substantially less time; in some cases in only one more semester of full-time study. A maximum of 15 credits may be used to satisfy the requirements of both degrees.

Students take additional credits shown below to fulfill requirements for the M.S. in Management. There is no thesis requirement.

At the time of admission to the dual degree program, the School of Management graduate advisor will determine if any M.S. in Management course requirements can be waived.

M.Arch. Requirements

Code	Title	Credits
Core Courses		
ARCH 500G	Advanced Architectural Graphics	3

ARCH 501G	Architectural Design I	6
ARCH 502G	Architectural Design II	6
ARCH 503G	Architectural Design III	6
ARCH 504G	Architectural Design IV	6
ARCH 541G	Construction I	3
ARCH 542G	Construction II	3
ARCH 543G	Environmental Control Systems I	3
ARCH 544G	Environmental Control Systems II	3
ARCH 545G	Structures I	3
ARCH 548G	Structures II	3
ARCH 547G	4D Integration	3
ARCH 528G	History of Architecture I	3
ARCH 529G	History of Architecture II	3
ARCH 555G	Architectural Graphics	3
ARCH 569G	Building and Development	3
ARCH 579G	Professional Architectural Practice	3
Two courses in architectural history [1,2]		6
One course in contemporary architectural theory [2]		3
Option Sequence		
Select two of the following:		12
ARCH 505G	Advanced Design Options I	
ARCH 506G	Advanced Design Options II	
ARCH 507G	Advanced Design Options III	
MARC 701	Master'S Thesis	
ARCH XXX	Electives [2]	9
Electives [2]		9
Total Credits		102

1. Including one course in non-western, regional, or vernacular architecture.
2. To be selected in consultation with the graduate advisor.

With the exception of History/Theory Selectives, ARCH 569G Building and Development and ARCH 579G Professional Architectural Practice, all core courses must be completed before proceeding to the options sequence.

M.S. in Management Requirements

Code	Title	Credits
Core Courses [1]		
ARCH 650	Economy Of Building	3
ARCH 651	Real Estate Analysis for Architects	3
ARCH 652	Architectural Project Management	3
FIN 516	Principles of Financial Management	3
HRM 601	Organizational Behavior	3
MGMT 680	Entrepreneurial Strategy	3
or MGMT 692	Strategic Management	
Required Course		
FIN 618	Public and Private Financing of Urban Areas	3
Electives		
Select three of the following:		9
ACCT 615	Management Accounting	
FIN 624	Corporate Finance II	
MGMT 640	New Venture Management	
MGMT 645	New Venture Finance	
MIS 645	Information Systems Principles	

MRKT 630	Models Of Consumer Behavior	
MRKT 638	Sales Management for Technical Professionals	
Total Credits		30

[1] ARCH 579G Professional Architectural Practice fulfills MGMT 691 Legal and Ethical Issues required for the M.S. in Management.

Master of Architecture and Master of Infrastructure Planning

This dual degree option is available to students in the M.Arch. degree program. The dual degree program permits students to obtain the M.Arch. and the M.I.P. in substantially less time than if each degree was pursued separately. M.Arch. students may partially fulfill M.I.P. course work while completing the M.Arch. program of study. A maximum of 15 credits may be used to satisfy requirements of both degrees.

For more information about the M.I.P. program, see Master in Infrastructure Planning (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/infrastructure-planning-masters/) in this catalog.

M.Arch. Requirements

Code	Title	Credits
Core Courses		
ARCH 500G	Advanced Architectural Graphics	3
ARCH 501G	Architectural Design I	6
ARCH 502G	Architectural Design II	6
ARCH 503G	Architectural Design III	6
ARCH 504G	Architectural Design IV	6
ARCH 541G	Construction I	3
ARCH 542G	Construction II	3
ARCH 543G	Environmental Control Systems I	3
ARCH 544G	Environmental Control Systems II	3
ARCH 545G	Structures I	3
ARCH 548G	Structures II	3
ARCH 547G	4D Integration	3
ARCH 528G	History of Architecture I	3
ARCH 529G	History of Architecture II	3
ARCH 555G	Architectural Graphics	3
ARCH 569G	Building and Development	3
ARCH 579G	Professional Architectural Practice	3
Two courses in architectural history [1,2]		6
One course in contemporary architectural theory [2]		3
Option Sequence		
Select two of the following:		12
ARCH 505G	Advanced Design Options I	
ARCH 506G	Advanced Design Options II	
ARCH 507G	Advanced Design Options III	
MARC 701	Master'S Thesis	
ARCH XXX	Electives [2]	9
Electives [2]		9
Total Credits		102

[1] Including one course in non-western, regional, or vernacular architecture.

[2] To be selected in consultation with the graduate advisor.

With the exception of History/Theory Selectives, ARCH 569G Building and Development and ARCH 579G Professional Architectural Practice, all core courses must be completed before proceeding to the options sequence.

M.I.P. Requirements

Code	Title	Credits
Required Courses		
MIP 631	History and Theory of Infrastructure	3
MIP 652	Geographic Information Systems	3
MIP 673	Infrastructure Planning in Practice	3
MIP 674	Infrastructure and Architecture	3
MIP 675	Elements of Infrastructure Planning	3
Additional Requirements		
MIP 601	Interdisciplinary Infrastructure Studio I	6
MIP 602	Interdisciplinary Infrastructure Studio II	6
MIP 612	Introduction to Environmental Policy Studies	3
EPS 622	Sustainable Politics and Policy	3
MIP 655	Land Use Planning	3
Total Credits		36

Master of Infrastructure Planning

Students must complete 36 course credits through full- or part-time study. Up to 6 credits toward the degree may be waived based on previous academic study. Additional elective courses may be taken in disciplines related to infrastructure planning, but do not count toward degree credit.

Required Courses

The following courses are required, subject to those waived in individual cases; however, no waivers will be given for studio courses. A typical full-time study plan over two semesters is shown below.

Course	Title	Credits
First Year		
1st Semester		
MIP 601	Interdisciplinary Infrastructure Studio I	6
MIP 631	History and Theory of Infrastructure	3
MIP 652	Geographic Information Systems	3
MIP 675	Elements of Infrastructure Planning	3
ARCH 647	Special Topics in Computer Applications	3
	Term Credits	18
2nd Semester		
MIP 602	Interdisciplinary Infrastructure Studio II	6
MIP 618	Public and Private Financing of Urban Areas [1]	3
MIP 655	Land Use Planning [1]	3
MIP 673	Infrastructure Planning in Practice	3
MIP 674	Infrastructure and Architecture	3
	Term Credits	18
	Total Credits	36

1 Or substitute selected with the approval of Graduate Advisor.

Ph.D. in Urban Systems

Ph.D. in Urban Systems

The Joint PhD Program in Urban Systems offers students opportunities to examine the complex relationships between physical, cultural, ecological, political, social, and economic aspects of cities in the U.S. and other countries, and to specialize in those topics of particular interest to them. With the exception of students pursuing a specialization in Urban History, the research approach in the program is based in the social sciences. Two senior public research universities in Newark co-sponsor the program: New Jersey Institute of Technology and Rutgers University-Newark. All students in the program have full access to library, computing, and other student services at both campuses.

The program gives students the tools to develop research-based knowledge in urban systems, to take an analytic view toward urban problems and to participate in the development and evaluation of policy and services for urban populations. The program consists of two tracks and one sub-specialization: (1) Urban Environment and a possible sub-specialization in Urban History in the School of Architecture at NJIT and (2) Global Urban Studies in the School of Arts and Sciences at Rutgers-Newark. All students in the program complete a 51-credit curriculum.

Urban Environment Track

Students in this track come to the program with previous degrees in architecture, landscape architecture, urban planning, political science and economics. Once in the program, they focus on the physical and spatial aspects of cities and larger metropolitan areas, taking a contemporary perspective, a historical perspective or a combination of both. They choose dissertation topics in architecture, landscape architecture, urban design, infrastructure, urban development, and urban agriculture, and pursue those topics in relation to social, cultural, ecological, and regulatory issues. Those who choose a sub-specialization in Urban History take courses in research methods related to that while other students in the track take research methods courses in the social sciences.

For information about Global Urban Studies at Rutgers-Newark, please see https://sasn.rutgers.edu/academics-admissions/graduate-programs/global-urban-studies-gus.

Admission to the Program

Criteria for admission to the program include a record of academic achievement, previous research experience, and a clear expression of research interests that are compatible with faculty expertise in the two universities. A completed master's degree is normally required of all applicants. Those applying directly from a Bachelor's degree program must have a cumulative undergraduate GPA of 3.75 or higher.

Students who are interested in the Urban Environment Track (including a specialization in Urban History) apply to NJIT (http://www.njit.edu/admissions/how-apply-graduate-admissions). Those interested in Global Urban Studies apply to Rutgers-Newark (https://sasn.rutgers.edu/academics-admissions/graduate-programs/global-urban-studies-gus). Acceptance into the program is decided jointly by coordinators of the two tracks.

The following items are required for application to the Urban Environment Track at NJIT:

Scores from the Graduate Record Examination (GRE)

Scores from Test of English as a Foreign Language (TOEFL) for international students

Official transcripts of all prior academic work

Three letters of recommendation (faculty preferred)

Written statement of purpose, including description of research interests

Interview (optional, at the discretion of track director)

More Information

For questions regarding the Urban Environment Track at NJIT please contact:

Fred Little, Graduate Program & Admissions Coordinator, School of Architecture, little@njit.edu   973.642.7576

Karen A. Franck, Professor, Coordinator of Urban Environment Track, School of Architecture, franck@njit.edu 347-229-2418.

For questions regarding the Global Urban Studies track at Rutgers-Newark, please contact the track coordinators:

Jamie Lew, Associate Professor, Department of Sociology and Anthropology, jamieLew@rutgers.edu 973-353-5130

Mara Sydney, Associate Professor, Department of Political Science, 973-353-5787 msidney@rutgers.edu

Degree Requirements

The curriculum for all Urban Systems students consists of a 9-credit core curriculum, a 12-credit research core, 18-credits of elective courses and a 12-credit dissertation sequence. Following completion of the core curriculum and the two required research courses, all students in the program must take and pass the qualifying examination in order to advance to doctoral candidacy and dissertation. Admission to the Urban Systems PhD Program is not a guarantee of success on the qualifying examination, or a guarantee of advancement to doctoral candidacy.

PhD Faculty, NJIT

Maurie Cohen, Professor, Department of Humanities, PhD, University of Pennsylvania

Zeynep Celik, Distinguished Professor, School of Architecture, PhD, University of California--Berkeley

Gabrielle Esperdy, Associate Professor, School of Architecture, PhD, City University of New York

Karen A. Franck, Professor, School of Architecture, PhD, City University of New York

Neil Maher, Professor, Federated Department of History, PhD, New York University

Stephen Pemberton, Professor, Federated Department of History, PhD, University of North Carolina at Chapel Hill

Anthony Schuman, Professor, School of Architecture, M.Arch, Columbia University

Darius Sollohub, Associate Professor, School of Architecture, M.Arch, Columbia University

Georgeen Theodore, Professor, School of Architecture, M. Arch, Harvard University

PhD Faculty, Rutgers Newark

Leyla Amzi-Erdogdular, Assistant Professor, Federated Department of History, PhD, Columbia

University

Ariane Chebel d'Appolonia, Professor, School of Public Affairs and Administration, PhD, Institut d'Etudes Politiques de Paris

Jamie Lew, Associate Professor, Department of Sociology and Anthropology, PhD, Teachers College, Columbia University

Sean T. Mitchell, Associate Professor, Department of Anthropology and Sociology, PhD, University of Chicago

Arthur Powell, Associate Professor, Department of Urban Education, PhD, Rutgers University, New Brunswick

Alan Sadovnik, Board of Governors Distinguished Service Professor, School of Public Affairs and Administration PhD, New York University

Mara Sydney, Associate Professor, Department of Political Science, PhD, University of

Colorado

Nükhet Varl#k, Associate Professor, Federated Department of History, PhD, University of Chicago

Core Curriculum

Urban Systems Curriculum (all courses are three credits)	Semster	University
Core (9 credits)		
History of the Global Metropolis (Arch 662-102)OR The Good City (USYS 711)	Fall	NJIT
Globalization, International Migration and Contemporary Cities (RU 26:834:690)OR Urban Governance in Global Perspective (RU 26:977:624:02)	Fall	Rutgers
Urban Theory and the Contemporary City (Arch 662-102)	Spring	NJIT/Rutgers
The Good City: Environmental Design and the Quality of Urban Life (USYS 711) OR History of the Global Metropolis (Arch 662-101)	Spring	NJIT
Urban Governance in Global Perspective (RU 26:977:624:02)OR Globalization, International Migration and Contemporary Cities (RU 26:834:690)	Fall	Rutgers
Core (9 credits)		
Qualitative Methods (RU 26.977.620)	Spring	Rutgers
Quantitative Methods (URB 6103)	Fall	RBHS
Additional research methods course		
Additional research methods course		
Electives (18 credits)Chosen in consultation with academic advisor and, eventually,dissertation advisor		

Dissertation research (12 credits)
Total credits (51)

Ying Wu College of Computing

The mission of the Ying Wu College of Computing, which was established in 2001, is to bring education in a broad range of computing disciplines to students on campus and at a distance to carry out cutting-edge research while working closely in the industry. Ying Wu College of Computing offers bachelor's, master's and doctoral degrees in multiple fields of computing science, Web and information systems and a multidisciplinary undergraduate degree in information technology.

Ying Wu College of Computing resides on one of the most computing-intensive campuses in the world, helping NJIT educate one of the largest groups of information technology students in the nation in the applications of new technologies as learning tools. Not coincidentally, New Jersey is one of the leading states for computing and high technology businesses. Thirty of the nation's fastest-growing technology companies are based in the state, and New Jersey ranks seventh in the nation as a cyberstate and eighth for venture capital investment— $3.5 billion—in information technology and software. Additionally, New Jersey offers the second-highest wages in the nation for technology workers. Ying Wu College of Computing graduates frequently land creatively satisfying and intellectually challenging jobs at major companies like IBM, Mercedes-Benz and Pfizer.

Programs

- Bioinformatics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/bioinformatics-ms/)
- Business & Information Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-ms/)
- Computer Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/ms/)
- Computing and Business - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/computing-business-ms/)
- Cyber Security and Privacy - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/cyber-security-privacy-ms/)
- Data Science - M.S (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/data-science-ms/)
- Information Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)
- Information Technology and Administration Security - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/administration-security-ms/)
- Software Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/software-engineering-ms/)

Programs

- Computer Science - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/phd/)
- Information Systems - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/phd/)

Programs

- Big Data Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/big-data-essentials-cert/)
- Business and Information Systems Implementation (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-cert/)
- Data Mining (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/data-mining-cert/)
- Data Visualization (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/data-visualization-cert/)
- IT Administration (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/it-administration-cert/)
- Information Security (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/information-security-cert/)
- Network Security and Information Assurance (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/network-security-information-systems-cert/)
- Software Engineering, Analysis, and Design (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/software-engr-analysis-design-cert/)
- Web Systems Development (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/web-systems-development-cert/)

Ying Wu College of Computing Courses

BNFO 601. Foundations of Bioinformatics I. 3 credits, 3 contact hours.
Introduction to script programming and basic biomolecular sequence analysis. Topics covered include sequence alignment, dynamic programming algorithms, hidden Markov models, and their implementation with a scripting language.

BNFO 602. Foundations of Bioinformatics II. 3 credits, 3 contact hours.
Topics in bioinformatics such as phylogeny reconstruction, genome-wide association study analysis, structure and sequence analysis, and machine learning and statistical approaches. Focus of the course is on a hands-on project on a contemporary bioinformatics problem.

BNFO 615. Data Analysis in Bioinformatics. 3 credits, 3 contact hours.
Students will learn machine learning methods. They will apply the methods to various problems in bioinformatics using the Python scikit machine learning library. Previous programming experience is required, previous knowledge of Python is a plus.

BNFO 620. Genomic Data Analysis. 3 credits, 3 contact hours.
This course will introduce students to the practice of analyzing large-scale genomic data generated by recent high throughput bio-techniques. It will cover microarray data and short-read sequencing data. It presents widely used analytical methods and software. The course includes several case studies on real large-scale genomics datasets. Students will gain practical experience in large-scale data analysis, which is highly desirable by both industry and academia employers.

BNFO 644. Data Mining and Management in Bioinformatics. 3 credits, 3 contact hours.
Concepts and principles of data management in bioinformatics. Presents methods for indexing, querying, and mining data obtained from molecular and evolutionary biology. Provides hands-on experience in designing a simple information system for querying and mining genomic data using ORACLE or MySQL.

BNFO 698. ST:. 3 credits, 3 contact hours.

BNFO 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in bioinformatics. A written report must be submitted to the project advisor. The student cannot register in BNFO 700B more than once and the incomplete (I) grade is not allowed.

BNFO 701B. Masters Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in bioinformatics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in BNFO 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

BNFO 701C. Masters Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in bioinformatics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (BNFO 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

BNFO 725. Independent Study. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

BNFO 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for BNFO 726 if they have taken BNFO 725 in a prior semester.

CS 505. Programming, Data Structures, and Algorithms. 3 credits, 4 contact hours.
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL or C. Computer science students cannot use this course for graduate degree credit. Intensive introduction to computer science principles: a procedure-oriented language such as C++; program design techniques; introductory data structures (linked lists, stacks, sets, trees, graphs); and algorithms (sorting, searching, etc.) and their analysis. Programming assignments are included.

CS 506. Foundations of Computer Science. 3 credits, 3 contact hours.
Prerequisite: knowledge of C/PASCAL. Corequisite: CS 505. Cannot be used for graduate credit towards the M.S. in Computer Science. Introduction to the concepts of iteration, asymptotic performance analysis of algorithms, recursion, recurrence relations, graphs, automata and logic, and also surveys the main data models used in computer science including trees, lists, sets, and relations. Programming assignments are given.

CS 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: students must have the approval of the co-op advisor for the CS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CS department in conjunction with the student and employer. Students must submit, for CS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CS 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Restriction: students must have the approval of the co-op advisor for the CS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CS department in conjunction with the student and employer. Students must submit, for CS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CS 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: graduate standing, and acceptance by the CS department and the Division of Career Development Services. Students must have the approval of the co-op advisor for the CS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate or graduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CS department in conjunction with the student and employer. Students must submit, for CS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CS 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CS 602. Java Programming. 3 credits, 3 contact hours.
Prerequisite: advanced Web-based programming with an emphasis on the Java language and platform. No prior knowledge of Java is required but students are expected to have a good understanding of object-oriented programming concepts such as encapsulation, inheritance, and polymorphism, experience with C++. Basic constructs and syntax and then the core advanced features. Topics include: networking and sockets, remote method invocation (RMI), database connectivity (JDBC), Java Beans, multi-threading and lighweight components (Swing). Common gateway interface (CGI) languages and browser scripting (JavaScript and VBScript) are discussed when used as a complement to the functionality of the Java language. Emphasis is on the latest version of Java, both deprecated methods and newly introduced features are discussed.

CS 608. Cryptography and Security. 3 credits, 3 contact hours.
This course involves computational methods providing secure Internet communication. Among the topics covered are: Security threats in communication systems; conventional cryptography: substitution and transposition codes; distribution of secret key over the Internet; principles of public-key cryptography; RSA and other public-key cryptographic methods; and digital signature protocol.

CS 610. Data Structures and Algorithms. 3 credits, 3 contact hours.
Prerequisite: CS 114 or CS 241 or equivalents (see undergraduate catalog for description). Intensive study of the fundamentals of data structures and algorithms. Presents the definitions, representations, processing algorithms for data structures, general design and analysis techniques for algorithms. Covers a broad variety of data structures, algorithms and their applications including linked lists, various tree organizations, hash tables, strings, storage allocation, algorithms for searching and sorting, and a selected collection of other algorithms. Programs are assigned to give students experience in algorithms, data structure design and implementation.

CS 611. Introduction to Computability and Complexity. 3 credits, 3 contact hours.
Prerequisite: CS 610. Introduces the theoretical fundamentals of computing, and provides an understanding of both the inherent capabilities and limitations of computation. The main models of computation are deterministic and non-deterministic Turing machines. Auxiliary models include partial and total recursive functions, first order logic, recursive and recursively enumerable sets, and symbol systems. Covers the essentials of computational theory: first order logic, Russel's Paradox, completeness and consistency, Goedel's Theorem, Church's Thesis, countable and uncountable sets, simulation and computation, diagonalization, dove-tailing, decidable and undecidable problems, reduction, recursion theory, Rice's Theorem, Recursion Theorem, execution time measures, P and NP, polynomial-time reduction, NP-completeness and NP-hardness and formal correctness semantics of programs.

CS 621. Numerical Analysis I. 3 credits, 3 contact hours.
Prerequisite: MATH 511 (see undergraduate catalog for description) or an introductory course in numerical methods. An introduction to computational aspects of scientific and engineering problems. Time-dependent phenomena and corresponding quantitative models. Numerical stability and conditioning. Approximation of functions. Interpolation, integration. Solution of nonlinear equations. Ordinary differential equations of the first order. Finite and iterative algorithms for solution of systems of linear equations. Emphasis on computer implementation of algorithms and application to variety of engineering problems.

CS 630. Operating System Design. 3 credits, 3 contact hours.
Prerequisites: CS 332, CS 432 (see undergraduate catalog for descriptions) and CS 505. An intensive study of computer operating system design including multiprogramming, time-sharing, real-time processing, job and task control, synchronization of concurrent processes and processors, resource scheduling, protection, and management of hierarchical storage.

CS 631. Data Management System Design. 3 credits, 3 contact hours.
Prerequisites: knowledge of C and data structures. Acquaintance with fundamental notions of relational database technology. Mathematical properties and usage of database programming languages. Methods of database design and conceptual modeling. Methods of physical storage for database information. Fundamental notions of concurrency control and recovery in database systems.

CS 632. Advanced Database System Design. 3 credits, 3 contact hours.
Prerequisites: CS 631 and good knowledge of a high-level programming language. Covers the rapidly changing concepts and principles of modern database systems and database programming based on SQL. Additional topics may include: advanced data modeling, OODBs, parallel and distributed database systems, XML and NO-SQL databases, Web-database systems, active databases, multimedia and text databases, database security, query optimization, indexing techniques, concurrency control, system performance, and data warehaousing.

CS 633. Distributed Systems. 3 credits, 3 contact hours.
Prerequisite: completion of bridge requirements. Fundamental topics concerning the design and implementation of distributed computing systems are covered, including interprocess communication, remote procedure calls, authentication, protection, distributed file systems, distributed transactions, replicated data, reliable broadcast protocols, and specifications for distributed programs. All topics will be illustrated with case studies. Optional topics may include synchronization, deadlocks, virtual time, and load balancing.

CS 634. Data Mining. 3 credits, 3 contact hours.
This course covers the principles of data mining system design and implementation. It presents methods for association and dependency analysis as well as classification, prediction, and clustering. Optional topics may include time series and graph mining, current trends in data mining, and data mining for scientific, medical and engineering applications.

CS 635. Computer Programming Languages. 3 credits, 3 contact hours.
Prerequisites: CS 505 and CS 510. The theory and design of computer language systems; the formal theory of syntax and language classification; a survey of procedure and problem-oriented computer programming languages, their syntax rules, data structures, and operations; control structures and the appropriate environments and methods of their use; a survey of translator types.

CS 636. Data Analytics with R Program. 3 credits, 3 contact hours.
Prerequisites: Entry-level courses in programming, probability and statistics (e.g. MATH333, CS280), or permission of the instructor. This course teaches data analytics with R programming. The student will learn and gain basic analytic skills via this high-level language. The course covers fundamental knowledge in R programming. Popular R packages for data science will be introduced as working examples. The course also includes case studies on data analytics projects. As a core course in data science, it provides skills that are highly desirable for both industry and academic employers.

CS 639. Elec. Medical Records: Med Terminologies and Comp. Imp.. 3 credits, 3 contact hours.
This course presents a graduate introduction to Medical Informatics for Computer Science students covering (1) the design, use and auditing of medical terminologies, such as the Unified Medical Language System (UMLS) and the Systematized Nomenclature of Medicine (SNOMED); and (2) principles of Electronic Medical Records (EMR), Electronic Health Records (EHR) and Personal Health Records (PHR), including issues of privacy and security.

CS 640. Recursive Function Theory. 3 credits, 3 contact hours.
Prerequisite: CS 540 or equivalent. Review of basic computability theory. Topics include Church's thesis; unsolvability results; creative, productive, and simple sets; computational complexity; P=NP problem; and classification of solvable problems according to their complexity.

CS 643. Cloud Computing. 3 credits, 3 contact hours.
Prerequisites: CS 633 or CS 656. This course presents a top-down view of cloud computing, from applications and administration to programming and infrastructure. Its main focus is on parallel programming techniques for cloud computing and large scale distributed systems which form the cloud infrastructure. The topics include: overview of cloud computing, cloud systems, parallel processing in the cloud, distributed storage systems, virtualization, secure distributed computing, and multicore programming.

CS 644. Introduction to Big Data. 3 credits, 3 contact hours.
Prerequisite: permission of the instructor. This course provides an in-depth coverage of various topics in big data from data generation, storage, management, transfer, to analytics, with focus on the state-of-the-art technologies, tools, architectures, and systems that constitute big-data computing solutions in high-performance networks. Real-life big-data applications and workflows in various domains (particularly in the sciences) are introduced as use cases to illustrate the development, deployment, and execution of a wide spectrum of emerging big-data solutions.

CS 645. Security and Privacy in Computer Systems. 3 credits, 3 contact hours.
Prerequisites: Students are expected to enter this course with a basic knowledge of operating systems, networking, algorithms, and data structures. Also, students should be able to program in Java and C/C++. The course covers fundamental principles of building secure systems and techniques to ensure data security and privacy. Topics include access control mechanisms, operating systems security, malicious code threats and software security, trusted computing, content protection, and database security . The course will also study existing technical approaches to protecting privacy, including Web anonymizers and ant-censorship tools, as well as policy and legal aspects of privacy.

CS 646. Network Protocols Security. 3 credits, 3 contact hours.
Prerequisites: CS 656 or ECE 637, and ability to program in Java and C/C++. This course covers the security of network protocols currently used on the internet. It seeks to familiarize students with common threats and network attacks, and provides an in-depth study of methods used to secure network communication. The course includes an applied component, which will help students gain practical experience in attacking and defending networked systems. Topics include authentication systems, and routing security, firewalls, intrusion detection, honeypots, wireless network security, malware, propagation and detection, and web security.

CS 647. Counter Hacking Techniques. 3 credits, 3 contact hours.
Prerequisites: CS 645 or CS 646 or CS 696 or ECE 638 or approval of the instructor. This course covers advanced techniques that can be used for offensive or defensive goals in network, computer systems and applications. The course follows a ?learning by doing? teaching approach through extensive use of virtual machines with vulnerable operating systems and applications. Topics covered include system memory organizations, CPU registers, assembly language fundamentals, GNU and Immunity debuggers, fuzzing based security testing development of local and remote Linux and Windows exploits, shellcode development, stealthy attacks, bypassing memory protection techniques, network and wireless hacking techniques, and ethical and legal implications of cyber-attacks.

CS 648. Cyber Sec Investigations & Law. 3 credits, 3 contact hours.
Prerequisites: CS 656 or IT 640 or permission of the instructor. This course will prepare students for a real-life experience for operating and protecting computer networks, data communication, and data storage systems. The course will provide the student with a methodology to examine and investigate intrusions and security of data storage, data management, and data transmission systems as a part of an integrated network. It will explore the various interfaces of these systems from a technical, human, and investigative perspective, and the potential legal issues. The course will provide the student with various fundamental legal knowledge necessary for a cyber practitioner: (a) basic intellectual property law including trade secrets and patents; (b) foreign viewpoints of intellectual property and compliance to include EU privacy law; (c) U.S. law of electronic surveillance, electronic search, and stored communications; (d) government and workplace consensual search and surveillance and consent banners/agreements.

CS 650. Computer Architecture. 3 credits, 3 contact hours.
Prerequisites: CS 251 (see undergraduate catalog for description) and CS 510. Exploiting instruction level parallelism (ILP) is central to designing modern computers. Presents design techniques used for such computers as IBM Power architectures, DEC Alpha, MIPS R4600, Intel P6, etc. Introduction of Instruction SET Architecture (ISA), various functional units, basic principles of pipelined computers. Modern techniques to ILP including superscalar, super-pipelining, software pipelining, loop unrolling, and VLIW. Memory hierarchy, including instruction cache, data cache, second level cache, and memory interleaving. Advanced computer architectures, including vector, array processors, interconnection technology, and ATM network of workstations. Hands-on experience designing a simple pipelined computer on screen and using CAD tools such as Cadence or ViewLogic.

CS 651. Data Communications. 3 credits, 3 contact hours.
Prerequisite: MATH 333 (see undergraduate catalog for description). Intensive study of the analytic tools required for the analysis and design of data communication systems. Topics include: birth-death queuing systems, Erlang's distribution, bulk-arrival and bulk-service systems, design and analysis of concentrators and multiplexers, elements of Renewal Theory, M/G/1 system, analysis of Time Division Multiplexing, priority queues, analysis of random access systems, time reversibility, open and closed queuing networks, mean value analysis, flow and congestion, control mechanisms, routing algorithms, flow models, and network topological design.

CS 652. Computer Networks-Architectures, Protocols and Standards. 3 credits, 3 contact hours.
Prerequisites: A high level programming language, MATH 333 (see undergraduate catalog for description), or instructor approved equivalents. Intensive study of various network architecture and protocol standards; with emphasis on the Open Systems Interconnetion (OSI) model. Topics include: analog and digital transmission, circuit and packet switching, the Integrated Services Digital Network (ISDN), Frame Relay, Broadband ISDN, Cell Relay, SONET, Local Area Networks (CSMA/CD, Token Bus, Token Ring, switched and isochronous Ethernets), Metropolitan Area Networks (FDDI, FDDI-II, DQDB), wireless and satellite networks, synchronization and error control, routing and congestion control, X.25 standard.

CS 656. Internet and Higher-Layer Protocols. 3 credits, 3 contact hours.
The course introduces the protocols and standards of the TCP/IP suite that govern the functioning of the Internet. The material covered in class is a top-down approach on introduction, discussion, and analysis of protocols from the data-link layer to the application layer. Alternative protocols to the TCP/IP suite and new protocols adopted by this suite are discussed. Numerical examples related to network planning and proocol functioning are analyzed.

CS 657. Principles of Interactive Computer Graphics. 3 credits, 3 contact hours.
Prerequisites: CS 505 or familiarity with the organization of at least one computer system, and knowledge of a structured programming language such as C. Graduate-level introduction to computer graphics concepts, algorithms, and systems. Includes 2-D raster graphics, algorithms, 2-D and 3-D geometric transformations, 3-D viewing, curves and surfaces. Emphasis on PC-based graphics programming projects. Principles of interactive graphics systems in terms of the hardware, software and mathematics required for interactive image production.

CS 659. Image Processing and Analysis. 3 credits, 3 contact hours.
Prerequisite: CS 505. Fundamentals of image processing, analysis and understanding. Topics include image representation, image data compression, image enhancement and restoration, feature extraction and shape analysis, region analysis, image sequence analysis and computer vision.

CS 660. Digital Watermarking. 3 credits, 3 contact hours.
Digital watermarking and steganography is important to ensure data security because of widely used digital multimedia and rapid growth of the Internet. Digital watermarking is a suitable tool to identify the source, creator, owner, distributor, or authorized consumer of a document or an image. Digital steganography aims at hiding digital information into covert channels, so one can conceal the information and prevent detection. This course intends to provide students an overview on different aspects of mechanisms and techniques for digital watermarking and steganography.

CS 661. Systems Simulation. 3 credits, 3 contact hours.
Prerequisites: an undergraduate or graduate course in probability theory and statistics, and working knowledge of at least one higher-level language. An introduction to the simulation of systems, with emphasis on underlying probabilistic and statistical methodologies for discrete-event simulations. Design of simulation applications, and simulation programming in a high-level language. Algorithms for the generation of pseudorandom numbers. Algorithmic methodologies for the simulation of discrete and continuous probabilistic processes. Use of statistical tools. Simulation of queuing systems. Applications of simulation to a variety of system studies. The special purpose simulation language GPSS is studied in detail.

CS 665. Algorithmic Graph Theory. 3 credits, 3 contact hours.
Prerequisite: CS 610. The elements of the theory of graphs and directed graphs with motivating examples from communication networks, data structures, etc; shortest paths, depth first search, matching algorithms, parallel algorithms, minimum spanning trees, basic complexity theory, planarity, and other topics. Programming assignments are included.

CS 666. Simulation for Finance. 3 credits, 3 contact hours.
Covers the use of Monte Carlo stochastic simulation for finance applications. Topics include generation of various random variables and stochastic processes (e.g., point processes, Brownian motion, diffusions), simulation methods for estimating quantities of interest (e.g., option prices, probabilities, expected values, quantiles), input modeling, and variance-reduction techniques. Students will write computer programs in C++. Students cannot receive credit for both CS 661 and CS/MATH 666.

CS 667. Design Techniques for Algorithms. 3 credits, 3 contact hours.
Prerequisite: CS 610. An introduction to the principles of major design techniques in algorithms. Examples from a variety of topics and problems in computer science are used to demonstrate these design techniques and their appropriate application.

CS 668. Parallel Algorithms. 3 credits, 3 contact hours.
Prerequisites: CS 610 and CS 650. This course examines a variety of parallel algorithms and architectures. Shared memory algorithms and algorithms for special architectures (tree processors, grids, systolic arrays, butterflies) are considered. The basic theory of algorithm/architecture performance will be described.

CS 670. Artificial Intelligence. 3 credits, 3 contact hours.
Prerequisite: CS 610. Fundamental concepts and general techniques in artificial intelligence. Main topics include goal tree search, logic and deduction, adduction, uncertainty, fuzzy logic, knowledge representations, machine learning, vision, and action planning. The LISP programming language is used extensively. Students are required to do programming assignments, complete a programming term project, and review case studies.

CS 673. Software Design and Production Methodology. 3 credits, 3 contact hours.
Prerequisite: CS 631. Modern techniques and methods employed in the development of large software systems, including a study of each of the major activities occurring during the lifetime of a software system, from conception to obsolescence and replacement. Topics include cost/performance evaluation, documentation requirements, system design and production techniques, system verification techniques, automated aids to system development, and project organization and management.

CS 675. Machine Learning. 3 credits, 3 contact hours.
Pre-requisites: Basic probability, linear algebra, computer programming, and graduate or undergraduate senior standing, OR approval of instructor. This course is an introduction to machine learning and contains both theory and applications. Students will get exposure to a broad range of machine learning methods and hands on practice on real data. Topics include Bayesian classification, perceptron, neural networks, logistic regression, support vector machines, decision trees, random forests, boosting, dimensionality reduction, unsupervised learning, regression, and learning new feature spaces. There will be several programming assignments, one course project, one mid-term and one final exam.

CS 676. Cognitive Computing. 3 credits, 3 contact hours.
Corequisites: CS 631. Prerequisite: Good knowledge of programming (C/C++/Java), or permission of instructor. This course provides an application oriented overview of Cognitive Computing, aimed at students specializing in data sciences. Cognitive algorithms (e.g. IBM, Stanford) that combine machine learning, data mining, AI and natural language will be used to build systems for finance, telecom and retail. Real world problems and data sets such as financial risk measurement or telecom churn will be introduced, and students will study and build Cognitive models on the IBM and open-source platforms. An important feature of this course is the usage of Harvard HBS case studies to illustrate current business challenges. This course will illustrate the development, deployment, and execution of a wide spectrum of Cognitive solutions.

CS 677. Deep Learning. 3 credits, 3 contact hours.
Prerequisites: CS 675 or approval of the instructor. This course covers current topics in data science. The topics include but are not limited to parallel programming on GPU and CPU multi-cores, deep learning, representation learning, optimization algorithms, and algorithms for big datasets. Students will present recent papers in data science, work on programming assignments, and do a machine learning/deep learning/data science project.

CS 678. Topics in Smartphone Sec & Rel. 3 credits, 3 contact hours.
This course covers current topics in the security and reliability of smartphones, and smartphone platform-based devices. The topics include but are not limited to understanding the software and hardware platforms; static and dynamic analyses for devices and apps; effective testing of devices and apps; formulating and launching attacks against these devices or apps, and understanding the security, privacy, and reliability risks that users expose themselves to when using such devices. The professor and students will present recent papers; discuss and critique papers, draw outlines for potential research explorations in this area; the students will complete a programming assignment designed to familiarize themselves with programming for the platform; the students will spend the rest of the individual work assignment on a project: running a research tool, designed to expose security and reliability issues, on popular platforms/apps/devices and reporting the findings.

CS 680. Linux Kernel Programming. 3 credits, 3 contact hours.
An in-depth study of how the Linux operating system is built from scratch. AS a hands-on course, students will perform intensive programming using Linux Kernel. The contents include machine booting, segmentation and paging memory management, creating and destroying processes, process switching and scheduling, handling exceptions and hardware interrupts, software interrupts, creating system calls, creating file systems, networking with TCP/IP, device driver writing and module programming, etc. At the end of the course, students will be able to modify Linux operating system to create their own.

CS 681. Computer Vision. 3 credits, 3 contact hours.
This course introduces computational models of computer vision and their implementation on computers, and focuses on material that is fundamental and has a broad scope of application. Topics include comtemporary developments in all mainstream areas of computer vision e.g., Image Formation, Feature Detection/Representation, Classification and Recognition, Motion Analysis, Camera Calibration, 3D/Stero Vision, Shape From X (motion, shading, texture, etc.), and typical applications such as Biometrics.

CS 683. Software Project Management. 3 credits, 3 contact hours.
This course gives the student the necessary background to allow her/him to manage software projects; this includes economic, managerial and organizational aspects. The essence of software engineering is not only to introduce a valuable software product, but to do so economically and competitively. Like any engineering discipline, software engineering depends critically on managerial, economic and organizational considerations. Students will learn software management technique, various software costing techniques including COCOMO and ROI, team organization and management, and various methods of software development including Cleanroom and Agile.

CS 684. Software Testing and Quality Assurance. 3 credits, 3 contact hours.
This course discusses software faults and techniques to reduce faults and improve software quality. Software systems are some of the most complex human artifacts ever built and also some of the most critical means to ensure our safety, well being, and prosperity. This course teaches techniques to ensure software systems perform their function correctly. Topics include software specifications, goals of testing, techniques of test data selection, test oracle design, test data analysis, test lifecycle and quality impacts of testing.

CS 685. Software Architecture. 3 credits, 3 contact hours.
The software architecture defines the structure and interactions of software modules. This course provides a working knowledge of the terms, principles and methods of software architecture and module design. It explains the constraints on the design and the properties of capacity, response time, and consistency. The "4+1" architecture model is taught with architectural styles, interface isolation, decoupling, reuse, agile design with software patterns, data structures, queuing effects, design simplification and refactoring. The non-functional requirements of reliability, performance and power consumption, component based design and good industry practices for documenting and managing the architectural process are taught.

CS 690. Software Studio. 3 credits, 3 contact hours.
Prerequisite: CS 673 or approval of the instructor. This course is the first of a two-course sequence (CS 690, CS 700B) that focuses on a team-based industrial scale software project. This two-course sequence is part of the required courses of the Master of Science in Software Engineering (MSSE). This course covers the early phases of the software lifecycle, including requirements analysis, requirements specifications, project planning, software architecture and product level design, along with associated documentation. This sequence is typically taken in the last year of the MSSE, and is intended as an opportunity for MSSE students to apply the material they have learned throughout the program.

CS 696. Network Management and Security. 3 credits, 3 contact hours.
Prerequisites: CS 652 or CS 656 or ECE 637 or ECE 683 Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and for protecting systems from network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms). Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). Same as ECE 638.

CS 698. ST:. 3 credits, 3 contact hours.

CS 700. Master'S Project. 0 credits, 0 contact hours.

CS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science. A written report must be submitted to the project advisor. The student cannot register in CS 700B more than once and the incomplete (I) grade is not allowed.

CS 701. Master's Thesis. 0 credits, 0 contact hours.

CS 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CS 704. Sequencing and Scheduling. 3 credits, 3 contact hours.
Advanced sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems are discussed in this course. Both deterministic and stochastic scheduling models are covered in detail. Heuristics and worst case analysis for "unsolvable" hard scheduling problems (NP-C problems) are introduced.

CS 708. Advanced Data Security and Privacy. 3 credits, 3 contact hours.
Prerequisites: CS 608, CS 645, CS 696, or instructor approval. In-depth study of the security and privacy issues associated with the massive amount of data that is collected, stored, shared and distributed in today's society. New paradigms are needed to address the security/privacy challenges when data is outsourced at untrusted servers (such as in cloud computing), when data is anonymized in order to be shared among untrusted parties, or when copyrighted data needs to be protected from unauthorized use.

CS 725. Independent Study in Computer Science I, II. 3 credits, 3 contact hours.
Approval of the academic advisor is required for registration. Students working on their PhD dissertation cannot register for both CS 725 and CS 726 with the same faculty. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CS 726. Independent Study II. 3 credits, 3 contact hours.
Approval of the academic advisor is required for registration. Students working on their PhD dissertation cannot register for both CS 725 and CS 726 with the same faculty. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CS 731. Applications of Database Systems. 3 credits, 3 contact hours.
Prerequisite: CS 631. Restricted to students who are specializing in computer and information systems management. Comparative study of different models of database management systems and their applications. Emphasis on the functions of the database administrator. Includes a survey of physical and logical organization of data, methods of accessing data, characteristics of different models of generalized database management systems, and case studies using these systems from various applications. Student teams design database systems for class projects.

CS 732. Advanced Machine Learning. 3 credits, 3 contact hours.
Prerequisites: CS 634 or CS 670. This course presents advanced topics in the machine learning field, with a focus on recent learning techniques developed for analysis of high dimensional data such as a model selection by regularization and ensemble learning. The course also covers the theory of supervised, semi-supervised, unsupervised, transduction and reinforcement learning, as well as applications of these learning methods.

CS 735. High Performance Analytics Dat. 3 credits, 3 contact hours.
Prerequisites: Knowledge of material from at least four courses in the following list: CS 631 (Data Management Systems Design), CS 634 (Data Mining), CS 643 (Cloud Computing), CS 644 (Introduction to Big Data), CS 675 (Machine Learning). Targeting the latest computing infrastructures and software systems for data analytics, this course introduces students to the design and analysis of scalable data science algorithms, as well as skills to implement high performance data science applications. Specific topics include in-memory data processing, column-oriented data storage and retrieval, cloud-based data intensive systems, as well as classic data analytics algorithms such as causal discovery and network inference and their scalable implementation.

CS 744. Data Mining and Management in Bioinformatics. 3 credits, 3 contact hours.
Prerequisites: CS 610 or permission of the instructor. Concepts and principles of bioinformatic data mining and management with focus on efficiency and scalability. Methods for indexing and querying biological databases, biological data mining, and algorithmic development for bimolecular and phlyogenetic data analysis. Trends and advances in areas such as functional genomics and proteomics, genetic engineering, and large-scale gene expression data analysis.

CS 750. High Performance Computing. 3 credits, 3 contact hours.
Prerequisite: CS 650. An in-depth study of the state of the art in high performance computing. Topics parallel computer architectures, programming paradigms, and their applications. Parallel architectures include PC clusters, shared-memory multiprocessors, distributed-memory multiprocessors, and multithreaded architectures. Parallel programming paradigms include message passing interface (MPI), its second-generation MPI-2, and multithreaded programming. Applications include computational science and high performance Web and database servers for Internet-based electronic commerce. Students program a parallel machine in class projects. First-hand experience in stable, scalable, high performance computing for Internet-based electronic commerce.

CS 755. Security and Privacy in Wireless Networks. 3 credits, 3 contact hours.
This course covers selected topics on security and privacy in wireless networks and is intended for graduate students who are interested in network security. This course can help the students learn the state of the art and open challenges in wireless network security and privacy, thus enhancing their potential to perform research or pursue a career in this emerging area.

CS 756. Mobile Computing and Sensor Networks. 3 credits, 3 contact hours.
This course provides an in-depth study of mobile computing and sensor networks, which are becoming major components of the transition from today's world of desktop computers to a world where computing is ubiquitous. The main topics include: techniques to handle mobility in the Internet and ad hoc networks; operating systems, programming languages, and protocols for sensor networks; applications, middleware, programming models, and security ubiquitous computing environments.

CS 759. Advanced Image Processing and Analysis. 3 credits, 3 contact hours.
Prerequisite: CS 659. Advanced study of recent research in image processing, analysis, and understanding. Topics include all image processing techniques, high-level recognition approaches, and automated expert vision systems.

CS 775. Seminar in Software Engineering. 3 credits, 3 contact hours.
Prerequisite: CS 673. A seminar in which students pursue intensive study of specialized topics in the current literature of software engineering. Each topic is supported by an initial reading list on current problems in theory and practice. The results of the studies are discussed in class with students, faculty and invited specialists.

CS 777. Seminar in Software Management and Production. 3 credits, 3 contact hours.
Prerequisites: Ph.D. core courses. A seminar in which students pursue intensive study of specialized topics in the current literature of software management and production. Each topic is supported by an initial reading list covering current problems in theory and practice. The results of the studies are discussed in class with students, faculty, and invited specialists participating. Topics include, but are not limited to, theory of algorithm structure, analysis of algorithms and programs, hardware technology assessment, automated tools for software production, software measurements and quality, peripheral device interfaces, data communications, computer networks, distributed processing, software verification, implementation standards, documentation standards, system security, software copyright, and project control and organization.

CS 782. Pattern Recognition and Applications. 3 credits, 3 contact hours.
Prerequisite: CS 610. Study of recent advances in development of (statistical and syntactic) pattern algorithm, approximation, and estimation techniques. Topics include statistical estimation theory, classifier design, parameter estimation and unsupervised learning, bias vs. variance, nonparametric techniques, linear discriminant functions, tree classifiers, feature extraction, and clustering. Additional topics include Support Vector machines (SVM), Bayesian Learning, Hidden Markov Models (HMM), evolutionary computation, neural networks, with applications to signal interpretation, time-series prediction, and Biometrics.

CS 785. Seminar in Computer and Information Science I. 3 credits, 3 contact hours.
Prerequisite: determined by nature of topic area. Advance notice of the topics to be covered is given. These seminars examine in depth a special interest area of computer and information science. It emphasizes recent work in area selected for the offering of the course. This course is for master's students and cannot apply toward master's degree credit.

CS 786. Special Topics. 3 credits, 3 contact hours.
Prerequisite: as determined by nature of topic area. A continuation of CS 785.

CS 790. Doct Dissertation & Res. 0 credits, 0 contact hours.

CS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: CS 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science. For PhD students who have successfully defended their dissertation proposal. The student must register in CS 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

CS 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CS 791. Since the CS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

CS 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: CS 791. Since the CS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in computer science. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

CS 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CS 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CS 790G. DOCT DISSERTATION & RES. 18 credits, 3 contact hours.

CS 791. Graduate Seminar. 0 credits, 0 contact hours.
Corequisite (for doctoral students only): CS 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in computer and information systems management. In the course students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

CS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: CS 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in computer science. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

CS 792C. Pre-Doctoral Research. 6 credits, 0 contact hours.

IS 513. Programming Foundations for IS. 3 credits, 3 contact hours.
This course is an introduction to the Java programming language teaching the foundations of writing, testing and debugging of programs. The course has three major parts. The first part teaches fundamental programming techniques that use primitive data types, variables, assignments expressions and operators, control statements, arrays and files I/O. The second part covers testing and debugging, and teaches students how to write programs that work reliably. The third part introduces object-oriented programming.

IS 531. Database Fundamentals. 3 credits, 3 contact hours.
This course gives students extensive, pragmatic experience in designing, building, querying, updating, maintaining and managing relational databases, using the Structured Query Language (SQL). We will start our journey by analyzing what database is and why it is superior to other data management methods. We will then conduct logical and physical database design. SQL will be extensively covered, and students will design and implement sophisticated SQL queries invoking self-joins, outer joins, correlated subqueries and related concepts. Hands-on experience will be gained by working with actual databases using industry-standard database management systems such as Oracle.

IS 565. Aspects Of Information Systems. 3 credits, 3 contact hours.
Methods and models of supporting the management process; ethical issues pertaining to the construction, deployment, and impact of information systems on organizations and society; description, analysis, and design of information systems to assist problem solving and decision-making in a business environment.

IS 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisite: students must have the approval of the co-op advisor for the Informatics department. Provides on-the-job reinforcement and application of concepts presented in the graduate IS curriculum. Work assignments are identified by the co-op office and developed and approved by the Informatics department in conjunction with the student and employer. Students must submit, for Informatics department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in IS.

IS 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisite: students must have the approval of the co-op advisor for the IS department. Provides on-the-job reinforcement and application of concepts presented in the graduate IS curriculum. Work assignments are identified by the co-op office and developed and approved by the Informatics department in conjunction with the student and employer. Students must submit, for Informatics department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in IS.

IS 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisites: graduate standing, and acceptance by the Informatics department and the Division of Career Development Services. Students must have the approval of the co-op advisor for the Informatics department. Provides on-the-job reinforcement and application of concepts presented in the graduate IS curriculum. Work assignments are identified by the co-op office and developed and approved by the Informatics department in conjunction with the student and employer. Students must submit, for IS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in IS.

IS 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

IS 601. Web Systems Development. 3 credits, 3 contact hours.
Prerequisites:NONE Students will gain experience in open source web development through an intensive hands-on project, applying real-world problem-solving skills to meeting information systems requirements. Students will learn Web development principles, as well as professionally relevant skills including industry standards, conventions, and procedures within large-scale programming projects. Also covered are the communication tools, technologies, and practices that individuals use to coordinate and collaborate within the open source software development community.

IS 612. Emergency Management Informatics. 3 credits, 3 contact hours.
This course covers core aspects of Emergency Management (EM) as they relate to information systems and usage of associated technologies. EM theory identifies four critical areas: 1) understanding & mitigating risk, 2) planning & preparedness, 3) reaction & response, 4) recovery & normalization. The role of informatics for each critical area will vary and is the basis for discussions and assignments. This course also focuses on innovative information systems approaches to EM in each area. Within the EM domain, business continuity (information processing and sharing during crisis situations), cyberterrorism, and international response are covered.

IS 613. Design of Emergency Management Information Systems. 3 credits, 0 contact hours.
This course is concerned with the development of requirements, the design of the human interaction, and the supporting functionality of any Information System related to the complete preparedness lifecycle for emergency, disaster, and crisis situations for government bodies, non-profit, and/or private organizations that are concerned with business continuity. It also focuses on organizational behavior and its effects on the functionality of the system and the design of the human interface.

IS 614. Command and Control Systems. 3 credits, 3 contact hours.
This course investigates the relevance and applicability of using of Command and Control (C2) models in organizational responses to both normal emergencies and catastrophic events. C2 refers to how leadership, authority, decision-making and coordination are assured within an organization, including distributed and virtual organizations. The course examines the functionality and properties of C2 systems in terms of matching requirements for these systems to the behavior of individuals, groups, and organizations during emergency conditions. It will address integrating systems and technologies within organizational emergency operations functions and processes to include business continuity and disaster response.

IS 616. Learning Methodologies and Training Technologies. 3 credits, 3 contact hours.
This course provides an overview of learning methodologies and training technologies, with an emphasis on emergency management. It reviews theories and develops skills for the planning, evaluation and selection of traditional and new technology-driven learning and training methods. Course participants will review relevant research and learn how to choose the most effective training methodologies, technologies and content resources appropriate to the needs of different audiences.

IS 631. Enterprise Database Management. 3 credits, 3 contact hours.
Prerequisites: IS 601 This course provides an understanding of the issues as well as hands-on experience in managing database systems as an essential organizational resource. Students will obtain a conceptual foundation of database design and explore the implications for organizational database usage. Students also will gain experience with enterprise database management systems, such as Oracle. This course introduces the design and management of enterprise-wide database systems. Topics include: (1) data modeling and database design; (2) database implementation with SQL; (3) database access standards for enterprise database systems; (4) multidimensional databases, online analytic processing (OLAP) and data warehousing, customer relationship management (CRM); and (5) web-based enterprise database systems.

IS 634. Information Retrieval. 3 credits, 3 contact hours.
Prerequisite: IS 601 Modern information retrieval systems, such as web search engines, empower users to easily access information on the web. The course covers the concepts and principles of information retrieval systems design, including web crawling, automatic indexing, vector space modeling, retrieval algorithms, digital libraries, text mining, information extraction, and document warehousing. These techniques are essential for building web systems, text databases, document processing systems, and other advanced information management systems.

IS 650. Data Visualization and Interpretation. 3 credits, 3 contact hours.
The course will focus on training students in data visualization techniques and relevant tools. They will learn theoretical aspects of visualization design, and gain practical experience in interpreting data as well as critiquing and comparing visualization techniques. They will develop interactive visualization interfaces as part of a class project. Students will also gain a broad understanding of how visualization can enhance data interpretation and play a key role in the data science pipeline. Finally, recent advances will be presented in the areas of information visualization, visual analytics, and human-data interaction.

IS 654. Visual Informatics for Social Network and Mobile Flow. 3 credits, 3 contact hours.
Prerequisite: IS 665 or equivalent. Nowadays, computational scientists are using network and flow to explore and analyze relationships among spatial objects. In the meantime, more and more virtual networks, such as Facebook and Twitter, have spatial characteristics which bring researchers opportunity to study spatial pattern of virtual network elements such as information diffusion and human behavior across space. This course will focus on substantive themes within network and flow. Visual informatics will be covered in this course followed by several case studies.

IS 657. Spatiotemporal Urban Analytics. 3 credits, 3 contact hours.
Prerequisite: IS 665 or equivalent. This course teaches essential concepts and skills needed to efficiently develop spatiotemporal thinking, create a spatiotemporal model, and visualize/model the urban spatiotemporal relationships in the open source environment. Students will learn about big data analytic skills that integrate large open source data and traditional data by investigating the relationship between virtual and physical worlds in the built environment.

IS 661. User Experience Design. 3 credits, 3 contact hours.
This is a foundation course on the design of digital products. User eXperience Design (UXD) isn't just about making interfaces usable. It is about designing and building relevant and successful products. Effective UXD requires a mix of Interaction Design (ID) methods and processes. This course takes you through the process of creating compelling interaction designs for digital products from the idea stage into creating a simple and intuitive user experience blueprint. You will 'learn by doing' in a team environment, enabling you to practice the techniques with coaching from instructors. The course will demystify Lean UX; Agile UX; Human Computer Interaction (HCI); Design Audits and Claims analysis; Persona construction; Storyboarding; ID scenarios; ID Frameworks; Role of user-research in UXD; and Design Patterns.

IS 663. System Analysis and Design. 3 credits, 3 contact hours.
Pre or Corequisite: IS 601 This course develops the skills necessary to analyze, design and manage the development of effective enterprise-scale information systems solutions incorporating contemporary methods and effective organizational and global project management practices. It focuses on technical business systems analysis and design techniques, and covers key software engineering principles, methods and frameworks, including process models, agile and lean principles, project and risk management, estimation, requirements elicitation and analysis, modeling, system and software architecture, design patterns, and quality systems. Students will actively participate in discussions, review selected articles, participate in team exercises and collaborate on projects involving analysis and prototyping of applications addressing real-world problems and integrating current and emerging technologies.

IS 664. Customer Discovery. 3 credits, 3 contact hours.
'Customer Discovery' is the term used by lean startup companies to describe the process of directly engaging with customers to explore potential new markets. Such evidence-based entrepreneurship guides the potential for new product ideas early in the development process. Similarly, high-tech innovators in new media, web, software apps, social networking, wearable computing, and mobile devices need to determine early on if their proposed solutions address real user needs. They do this by understanding potential user's practice, preferences and mental models. As a result, knowledge of a basic set of qualitative customer discovery methods is essential for both the lean startup entrepreneur and those engaged in interaction design innovation. This course teaches these methods through hands-on team projects. Students will design and run interview and diary studies, thinking out-loud protocols and focus groups, and analyze and report on findings. Students will explore over the course of the semester a problem domain and gain understanding of customer needs that will serve as a foundation for high-tech, innovative product design.

IS 665. Data Analytics for Info System. 3 credits, 3 contact hours.
Prerequisite: IS 601 This course gives a graduate level introduction to data analysis, probability and statistics from an information systems perspective, including many of the techniques that are most relevant to the profession of Data Scientist for business, data and web analytics, as well as current data sets. We will learn and conduct Python, MATLAB and R based manipulation of data. Course topics include the rudiments of probability and random variables, estimation, special distribution and sampling, Markov processes, hypothesis testing, graphics and visualization.

IS 676. Requirement Engineering. 3 credits, 3 contact hours.
Prerequisites or Corequisites: IS 663 or CS 673 or equivalent project experience in the field. Requirements engineering is one of the all-important beginning stages of the systems development life cycle. Revealing and understanding the system's requirements is a crucial component of success for developing new computing systems or adjusting existing applications. This course covers the theory, principles, and practical application of the methodologies and tools for requirements engineering. The focus is development of large software systems and the integration of multiple systems into a comprehensive, domain dependent solution. All aspects of requirements engineering including the knowledge and skills needed to elicit and analyze requirements, translate these requirements into technical specifications, verify that the requirements accurately capture the system requirements, and manage software requirements through the system development cycle will be covered. Students will actively participate in discussions, labs and exercises, and prepare operational requirements and technical specifications for real-world problems. We will spend a considerable amount of time interacting and learning through discussion of assigned readings and other material.

IS 677. Information System Principles. 3 credits, 3 contact hours.
This course introduces the field of Information Systems; the study of how people and organizations should use information technologies effectively. We examine the major areas in the field, analyzing the major issues, trends and problems. We survey the role of information systems in organizations and how these systems support organizational objectives and organizational structure, as well as providing competitive business advantages. We discuss basic concepts such as the systems point of view, the organization of a system, the nature of information and information flows, as well as how people process information and related cognitive concepts. We also examine various types of information system applications such as e-commerce, supply chain, decision support, and enterprise systems. And, finally, we also consider critical ethics issues including privacy, personalization and security.

IS 678. IT Service Management. 3 credits, 3 contact hours.
Prerequisites: IS 663 or CS 673 This course introduces the Information Technology Infrastructure Library (ITIL) fundamentals of the service management life cycle-service strategy, service design, service transition, service operation, and continual service improvement. ITIL provides a comprehensive, consistent, and coherent framework of best practices for IT Service Management (ITSM), which promotes a quality approach for achieving business effectiveness and efficiency in the use of information systems. This course presents the basic terminology and an overview of the functions and processes for each of the life cycle phases as they apply to IT Management. Although ITIL is originally presented as an approach for designing IT processes, we can expand this view and apply it to the design of other business services. Possible semester-long contexts are the processes of an educational services provider or health care services provider.

IS 680. Information Systems Auditing. 3 credits, 3 contact hours.
Due to the dynamic nature of information technology, the need arises continually to redefine audit, control and security requirements and processes. Topics include the IS audit process, IT infrastructure and operations, information protection, disaster recovery and business continuity, IT service delivery and support, business application systems, and project management. Students gain practical experience with each by working through a series of sample Certified Information Systems Audit (CISA) exam questions.

IS 681. Computer Security Auditing. 3 credits, 3 contact hours.
This course reflects the current emphasis on information security and security management in Fortune 500 corporations. Students will delve into information protection concepts, privacy impact analysis, computer crime, legal issues, controls and auditing systems, and firewall configuration. Students will have the opportunity to learn and perform evaluations on security infrastructures in a controlled environment in class labs by completing realistic security auditing projects and using vulnerability assessment tools to assess risks and evaluate security controls on networked infrastructures.

IS 682. Forensic Auditing for Computing Security. 3 credits, 3 contact hours.
A computer forensics audit is the proper identification and collection of computer evidence. Computers are involved in security violations through crime or violations of policy, or being targeted by an attack. This course deals with the preservation, identification, extraction, documentation, reporting, acquisition, analysis and interpretation of computer data. Topics covered include evidence handling, chain of custody, collection, preservation, identification and recovery of computer data. In this hands-on course, you will conduct several labs where you will be taught to analyze, review and extract information from computer hard drives, and determine what and how the information could have been compromised. Computer Forensics Audit professionals become experts in e-discovery and preserving sensitive evidential matter.

IS 683. Web Systems Development. 3 credits, 3 contact hours.
Students will gain experience in open source web development through an intensive hands-on project, applying real-world problem-solving skills to meeting information systems requirements. Students will learn Web development principles, as well as professionally relevant skills including industry standards, conventions, and procedures within large-scale programming projects. Also covered are the communication tools, technologies, and practices that individuals use to coordinate and collaborate within the open source software development community.

IS 684. Business Process Innovation. 3 credits, 3 contact hours.
Prerequisites: IS 663 or CS 673 This course adopts a balanced approach to business process innovation (BPI) that includes both incremental improvement and re-engineering. It specifically examines the concept of a service-oriented architecture (SOA) and the use of web services as a way to enable scalable and adaptive business processes. Students will learn how to develop process maps using the Business Process Modeling Notation (BPMN) and design process improvements to achieve efficiency, effectiveness, compliance and agility objectives. The focus of the course is on ways in which information technology can be used to manage, transform and improve business processes.

IS 685. Enterprise Architecture and Integration. 3 credits, 3 contact hours.
Prerequisites: None, but recommend completion of IS 663 or CS 673. The Enterprise Architecture (EA) describes an organization's IT strategy and operational structure. IS and IT professionals utilize the EA to analyze, design and integrate the (often heterogeneous) IT infrastructure and applications to most effectively support the enterprise and respond to risks. Students learn to develop an EA analysis which reflects its business strategies, capabilities, processes, and systems, metrics, information resources, and networking infrastructure. This enables students to determine the impact of IT solutions, by learning to deconstruct, analyze and configure IT systems in alignment with enterprise-wide business strategies. The course covers the industry standard The Open Group Architecture Framework (TOGAF) enterprise architecture framework and focuses on Enterprise Application Integration (EAI).

IS 686. Pervasive Computing: An HCI Perspective. 3 credits, 3 contact hours.
This course examines Pervasive/Ubiquitous Computing, the trend toward increasingly ubiquitous connected computing devices in the environment - a trend being brought about by a convergence of advanced electronic, and particularly, wireless technologies and the internet. We do this from a Human Computer Interaction perspective looking at the current and future design of various systems.

IS 687. Transaction Mining and Fraud Detection. 3 credits, 3 contact hours.
Prerequisite: IS 665 Increasingly, all of our transactions are electronic. We use debit and credit cards (electronic transactions) instead of checks and cash at banks, restaurants, stores, and many other businesses. Evaluation of transactions to find risk includes detection of terrorists and money launderers. Every financial institution is legally required to monitor transactions to detect organized crime and terrorism. Mining transaction streams to find good or bad customers is a rapidly growing area of employment for IS graduates. This course will present methods that are being used to analyze and mine transactional data and the business applications of these methods.

IS 688. Web Mining. 3 credits, 3 contact hours.
Prerequisite: IS 665. Web mining aims to discover useful information and knowledge from the Web hyperlink structure, page contents and usage logs. It has direct applications in e-commerce, Web analytics, information retrieval/filtering, personalization, and recommender systems. Employees knowledgeable about Web mining techniques and their applications are highly sought by major Web companies such as Google, Amazon, Yahoo, MSN and others who need to understand user behavior and utilize discovered patterns from terabytes of user profile data to design more intelligent applications. The primary focus of this course is on Web usage mining and its applications to business intelligence and biomedical domains. We learn techniques from machine learning, data mining, text mining, and databases to extract useful knowledge from the Web and other unstructured/semistructured, hypertextual, distributed information repositories. This data could be used for site management, automatic personalization, recommendation, and user profiling. Topics covered include crawling, indexing, ranking and filtering algorithms using text and link analysis, applications to search, classification, tracking, monitoring, and Web intelligence. Programming assignments give hands-on experience. A group project highlights class topics.

IS 690. Web Services and Middleware. 3 credits, 3 contact hours.
Prerequisite: IS 601 Web services enable integration of web-based applications and feature sets to any other web-based system in a modular way. Middleware is a set of functionality positioned in between and enabling interoperability among different, distributed enterprise and other computing applications. This course provides an introduction to web services and middleware in the context of digital libraries - large scale multimedia information repositories. Students will gain hands on experience in developing their own web services managing a complex distributed computing platform.

IS 698. Special topics in Information Systems. 3 credits, 3 contact hours.
Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

IS 700. Master's Project. 0 credits, 0 contact hours.
An approved project involving design, implementation, and analysis, or theoretical investigation, under the guidance of a faculty member. Students are strongly advised to work with the faculty member to develop a project proposal during the semester prior to conducting the master's project. Approval to register for the project must be obtained from the faculty member advising the project.

IS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in information systems. A written report must be submitted to the project advisor. The student cannot register in IS 700B more than once and the incomplete (I) grade is not allowed.

IS 700C. Master's Project. 6 credits, 6 contact hours.
An approved project involving design, implementation, and analysis, or theoretical investigation, under the guidance of a faculty member. Students are strongly advised to work with the faculty member to develop a project proposal during the semester prior to conducting the master's project. Approval to register for the project must be obtained from the faculty member advising the project.

IS 701. Master's Thesis. 0 credits, 0 contact hours.
An approved research-oriented project involving design, implementation, and analysis or theoretical investigation, carried out under the supervision of a faculty member who will be the thesis advisor. The thesis should be of such depth and caliber as to warrant publication in a technical or scientific journal. Approval to register for the thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits required for the thesis. Students are strongly advised to work with the thesis advisor to develop a thesis proposal during the semester prior to commencing the project.

IS 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in information systems that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in IS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

IS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in information systems that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (IS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

IS 725. Independent Study in Information Systems. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

IS 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for IS 726 if they have taken IS 725 in a prior semester.

IS 727. Independent Research III. 3 credits, 1 contact hour.

IS 735. Social Media. 3 credits, 3 contact hours.
Prerequisite: IS 665 or MATH 661, or a graduate course in statistics or course in quantitative research methods. Seminar style course that covers design and impact of computer-based systems for human communication, including email and IM, discussion boards, Computer-Supported Cooperative Work (CSCW), Group Decision Support Systems (GDSS), and Social Networking Systems. Topics include alternative design structures, impacts of primarily text-based group communication, and recent empirical studies of virtual teams, online communities, and systems used for social networking, including 3-D worlds such as Second Life and "micro blogging" systems such as Twitter.

IS 764. Research Methods for Human-Centered Computing and Design. 3 credits, 3 contact hours.
Prerequisites: None. This introductory seminar in human centered computing and design provides a survey of the methodological literature on qualitative research methods paired with appropriate article-length exemplars. We cover a variety of different research strategies including design science, action research, case study, qualitative data collection and analysis techniques, and scenario-based design. This course develops skills in designing and evaluating systems using qualitative methods. We also discuss writing and reviewing academic articles and research proposals. The course utilizes information systems as the primary domain but could be extended for students in other disciplines.

IS 765. Quantitative Methods in Information Systems Research. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or equivalent. This course is a practical and project-oriented introduction to quantitative and qualitative methods in information systems (IS) research that use human subjects. The focus of the course is on developing researchers' capability to select and implement appropriate data collection and statistical analysis procedures for a variety of research questions and to interpret the results of these procedures.

IS 766. Philosophy of Information Science. 3 credits, 3 contact hours.
This seminar explores central issues in contemporary philosophy of science. We consider "scientific" progress in the computing sciences with a focus on information systems and human computer interaction theory. We discuss topics such as confirmation and disconfirmation of theories; falsifiability and pseudo-science; introduction; probability; and statistical inference, prediction, explanation and empirical equivalence. We read key works by philosophers such as Popper and Kuhn. We examine the notion of "design science" and contrast it with "natural science", and examine whether social science research should strive to emulate natural science methods. Readings will be tied into research within information systems and the computing sciences in general, looking at how scientific theories are tested or confirmed.

IS 776. IS Research Study. 3 credits, 3 contact hours.
Prerequisite: Restricted to students in the doctoral program in Information Systems. The IS Research Study serves as the Information Systems PhD qualifying exam and demonstrates research readiness. Each student works with a faculty member to identify the topic of a research study, and then takes the lead in designing and conducting the study, and analyzing the results.

IS 785. Special Topics. 3 credits, 3 contact hours.
These seminars examine a special interest area of Information Systems in depth. Each seminar emphasizes recent work in the area selected.

IS 786. Special Topics. 3 credits, 3 contact hours.
These seminars examine a special interest area of Information Systems in depth. Each seminar emphasizes recent work in the area selected.

IS 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: IS 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in information systems. For PhD students who have successfully defended their dissertation proposal. The student must register in IS 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

IS 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: IS 791. Since the IS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in information systems. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

IS 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: IS 791. Since the IS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in information systems. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

IS 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790F. Doct Dissertation & Res. 15 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 791. Doctoral Seminar. 0 credits, 0 contact hours.
A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in information systems. In the course students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

IS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: IS 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in information systems. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

IT 610. Systems Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course is an introduction to the skills needed for and tasks performed by a System Administrator. The course will cover administration of host and server systems in modern operating system environments. Topics to be covered include: user, configuration, and change management, shell scripting, monitoring and performance analysis, disaster mitigation and recovery, and auditing.

IT 620. Wireless Networks Security and Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course introduces the fundamentals of wireless network security and administration. Topics include: wireless LAN vulnerabilities, passive and active wireless attacks, enterprise wireless hardware security, secure wireless authentication and communication, wireless intrusion detection and prevention systems, WiFi and cellular network management, location privacy, personal area network administration and security, mobile IP security, GSM, CDPD, 3G and 4G network security. The course provides both a theoretical foundation and hands-on experience in these areas.

IT 635. Database Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course provides a broad overview of the tasks and techniques necessary to function as a Database Administrator (DBA)in a modern relational database environment. Students will learn the duties typically performed by a DBA, which include: user authorization, disaster planning and recovery, monitoring, performance analysis, database tuning, metadata maintenance as well as data modeling, analysis and database design.

IT 640. Network Services Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course provides an introduction to the fundamentals of network services administration. It covers how web-based and domain-services operate, integrate and communicate. Topics include: fundamental technologies that underpin the web services paradigm, key standards necessary for their development, and how other critical domain services should be deployed. This course will enable students to gain skills necessary to plan, install, configure, secure and maintain web servers, DNS servers, email & print servers, resource sharing systems, and domain authentication systems.

IT 725. Independent Study. 3 credits, 3 contact hours.

YWCC 691. Graduate Capstone Project. 3 credits, 3 contact hours.
Prerequisites: CS 602 and CS 610, or equivalents. The course will focus on providing students experience with industry or faculty sponsored projects involving real situations to apply acquired knowledge including latest in software engineering and programming tools. Projects usually include a broad array of hard-core software engineering applications as well as projects in apps development, web development, game development, virtual reality, multimedia, web and network security and much more. The students will also read, discuss and critique papers, and other recent progress in large software development. If the course is used as an MS project to satisfy a program's requirements, it is the student's responsibility to ensure, in consultation with the Director of the program, that the chosen project meets the requirements of the program.

Computer Science

Computer Science

The Department of Computer Science is distinguished by prominent researchers who are actively investigating new applications in parallel processing and advanced computer architecture, systems integration, real-time computing, neuroscience and robotics, medical imaging, combinatorial computing, bioinformatics, computer vision and image processing, and software engineering.

The department provides an environment that gives students the background and skills necessary for entry into today's workplace. This is achieved through team research in state-of-the-art facilities; a faculty that works steadily in the forefront of many research areas; interaction with industry and experts; and an administration focused on research and student services. As a result, the department attracts the largest student population for computer and information science in the greater New York/New Jersey area.

The computer science department maintains and offers computing facilities for its students, faculty, and staff. The computing facilities include research laboratories housing research in areas of computer science such as: networking, real-time systems, hypermedia, parallel processing, and collaborative systems. Users have access to the state-of-the-art software and hardware including Oracle database, UNIX-based workstations and Microsoft Windows PCs supported by several file and compute servers. Internet access, departmental intranets, and conferencing systems provide an integrated infrastructure for supporting teaching and research.

Master of Science in Computer Science

The Master of Science (MS) in Computer Science (CS) is intended for students who are interested in pursuing advanced studies in computer science.

Admission Requirements

- GPA
  - 3.0 out of 4.0 required for students with a computer science background.
  - 3.0 out of 4.0 required for students without a computer science background who may be required to enroll in bridge courses.
- International students TOEFL score: the Institute requires a minimum score of 213 **paper based or 79 online.**
- International students: GRE required.
- Students with a US or Canadian degree in computer science or engineering: GRE recommended but not required.
- Students with a US or Canadian degree not in computer science or engineering: GRE required.

Students who lack a comprehensive computer science background may be required to take appropriate bridge courses and attain a minimum cumulative GPA of 3.0 in the bridge courses.

Students are expected to have good programming skills, and a grasp of the fundamentals of computer science (students should have acquired this knowledge in the undergraduate degree Bachelor of Science in Computer Science or equivalent degree). To ensure that students have the background to do well and succeed in doing the MS in Computer Science at NJIT, they will be required to take a short answer exam to demonstrate that they have good programming skills (in C++ or Java) and that they know the basic concepts of operating systems, networking, and databases. Students who do not do well in the exam are offered the opportunity to improve their skills via bridge courses.

Note that credits earned in the bridge program cannot count towards the MS program. However, grades of 500-level bridge courses contribute towards the graduate GPA. Students must maintain a cumulative graduate GPA of 3.0 or better.

If a student satisfies a bridge requirement before matriculation, the student can request a bridge course waiver which must be filed no later than the end of the first semester of studies and accompanied by all relevant documentation as required by University regulations. See Academic Policies and

Procedures in the NJIT Graduate Catalog at http://catalog.njit.edu/graduate/academic-policies-procedures/ (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/).

PASS/FAIL courses, professional development courses, work experience, or a course with a grade less than B (or equivalent) cannot be used to satisfy a bridge course requirement. Grades in the bridge program (500-level courses or higher) contribute to the cumulative graduate GPA. However, these courses do not count toward the MS program credit requirements. The undergraduate catalog, http://catalog.njit.edu/undergraduate/computing-sciences/computer-science/#coursestext (http://catalog.njit.edu/archive/2019-2020/undergraduate/computing-sciences/computer-science/#coursestext), contains descriptions of undergraduate courses included in the bridge program.

Application Processing

The Computer Science Department reviews only completed applications submitted to the Office of Graduate Admissions. Applicants are advised to request status information on their application directly from the Graduate Admissions Office, not the Computer Science Department. Graduate Admissions can be reached at admissions@njit.edu or www.njit.edu/gadmission (http://www.njit.edu/gadmission/) or by mail at NJIT, Graduate Admissions Office, University Heights, Newark NJ 07102.

Bridge Courses

Students who intend to pursue an MS degree in Computer Science are expected to have a certain background in Computer Science and Mathematics. A student who does not have this background may need to enroll bridge courses before taking graduate level Computer Science courses. This will help ensure success in the MS program. These students will be notified in their acceptance letter that bridge courses are a condition of their acceptance into the Master's Program. If a student's acceptance letter indicates bridge courses are required, they must contact the Graduate Advisor. If the acceptance letter does not indicate bridge courses, none are required and the student may immediately begin taking graduate courses. A student must maintain a cumulative GPA of 3.0 in bridge courses. Bridge courses do not count towards MS degree requirements; however, they count toward the cumulative graduate GPA.

Bioinformatics

Admission Requirements

- BS or BA Degree is Computing, Biology, or related discipline. TOEFL and GRE required for international students..
- Computer courses in programming & data structures equivalent to CS 113 Introduction to Computer Science & CS 114 Introduction to Computer Science II.
- One or more courses in genetics or molecular biology, equivalent to R120 352 Genetics or R120 356 Molecular Biology.
- Mathematics courses in calculus equivalent to MATH 111 Calculus I & MATH 112 Calculus II.

If the prerequisites are not fulfilled, completion of specific bridge courses will be required as a condition of admission.

Computing and Business

Technology and Science are dramatically changing our economy and our society. This is creating new business opportunities and needs, with an increasing push for computing employees to be more involved in business aspects of a company. Computing employees must have a solid understanding of business fundamentals to succeed. Specifically designed to address theses issues, the Master of Science (MS) in Computing and Business degree is primarily for people who want to develop, use, and manage software applications and systems in a business environment.

Offered by the College of Computing Sciences, the MS in Computing and Business contains a mix of courses in computer science and business. With one of the most computing intensive campuses in the world, NJIT has pioneered in the applications of new technologies as learning tools. The College of Computing Sciences educates one of the largest groups of information technology students in the nation.

Cyber Security and Privacy

Admission Requirements

To be eligible for admission, a student must have completed an undergraduate degree, preferably in Computer Science, Computer Engineering, Information Systems, Information Technology, or a related field, with a minimum GPA of 3.0 on a 4.0 scale. Students not satisfying these criteria will be considered for conditional admission on a case-by-case basis. This includes students whose bachelor's degree is in a non-computing field but have professional experience in computing or systems administration. Any such student who is admitted will be required to complete the following bridge courses with a GPA of 3.0 or higher: CS 505 Programming, Data Structures, and Algorithms, CS 506 Foundations of Computer Science. The bridge courses will not be counted toward the MS degree.

Application Processing

The Computer Science Department reviews only completed applications submitted to the Office of Graduate Admissions. Applicants are advised to request status information on their application directly from the Graduate Admissions Office, not the Computer Science Department. Graduate Admissions can be reached at admissions@njit.edu or www.njit.edu/gadmission (http://www.njit.edu/gadmission/) or by mail at NJIT, Graduate Admissions Office, University Heights, Newark NJ 07102.

Software Engineering

Software engineering is the disciplined application of computer science knowledge to the analysis, design, development, evaluation and evolution of software products. Because software pervades economic and personal activity worldwide and because it is increasingly being used in critical applications, the software industry is under intense pressure to deliver quality software. Because software production remains a labor intensive activity, the demand for large volumes of high quality software translates into high demand for qualified software engineers. *MS in Software Engineering* consists of a judicious balance of theoretical computer science foundations that afford graduates the means to remain abreast of developments in software engineering in the long term and practical applications that afford graduates the means to be operational in the short term.

Admission Requirements

Applicants are expected to have completed an undergraduate degree in computer science, information systems, information technology, or another computing related field. Students lacking the appropriate background will be considered for conditional admission on a case-by-case basis and may be required to take bridge courses (bridge courses do not count for credit towards the degree).

NJIT Faculty

B

Bader, David, Distinguished Professor

Basu Roy, Senjuti, Assistant Professor

Borcea, Cristian M., Professor

C

Calvin, James M., Professor

Curtmola, Reza, Professor

D

Dass, Ananya, University Lecturer

Ding, Xiaoning, Associate Professor

E

Eljabiri, Osama, Senior University Lecturer

G

Gehani, Narain, Professor, Emeritus

Geller, James, Professor

Gerbessiotis, Alexandros, Associate Professor

Gotsman, Craig J., Distinguished Professor and Dean

H

Hung, Daochuan, Associate Professor

I

Itani, Abdul-Rahman M., Senior University Lecturer

K

Kapleau, Jonathan, J., University Lecturer

Karvelas, Dionissios, Senior University Lecturer

Koutis, Ioannis, Associate Professor

Kwestel, Morty D., Senior University Lecturer

L

Li, Jing, Assistant Professor

Liu, Chengjun, Professor

M

Mani, Kumar, Professor

McHugh, James, Professor

Mili, Ali, Professor

N

Nakayama, Marvin K., Professor

Nassimi, David, Associate Professor

Neamtiu, Iulian, Associate Professor

Nicholson, Theodore L., Senior University Lecturer

O

Oria, Vincent, Professor

P

Perl, Yehoshua, Professor

Polyakov, Yuriy S., Associate Research Professor

R

Rohloff, Kurt, Associate Professor

Roshan, Usman W., Associate Professor

Rutkowski, Wallace, Senior University Lecturer

Ryan, Gerard W., Senior University Lecturer

S

Shih, Frank Y., Professor

Sohn, Andrew, Associate Professor

Spirollari, Junilda, Senior University Lecturer

T

Tang, Qiang, Assistant Professor

Theodoratos, Dimitrios, Associate Professor

Thomson, Susan E., Senior University Lecturer

W

Wang, Jason, T., Professor

Wang, Guiling (Grace), Professor

Wei, Zhi, Professor

Wu, Chase Q., Professor

Programs

- Bioinformatics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/bioinformatics-ms/)
- Computer Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/ms/)
- Computing & Business - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/computing-business-ms/)
- Cyber Security & Privacy - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/cyber-security-privacy-ms/)
- Data Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/data-science-ms/)
- Software Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/software-engineering-ms/)

- Computing Sciences - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/phd/)

Programs

- Big Data Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/computer-science/big-data-essentials-cert/)

Computer Science Courses

CS 505. Programming, Data Structures, and Algorithms. 3 credits, 4 contact hours.
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL or C. Computer science students cannot use this course for graduate degree credit. Intensive introduction to computer science principles: a procedure-oriented language such as C++; program design techniques; introductory data structures (linked lists, stacks, sets, trees, graphs); and algorithms (sorting, searching, etc.) and their analysis. Programming assignments are included.

CS 506. Foundations of Computer Science. 3 credits, 3 contact hours.
Prerequisite: knowledge of C/PASCAL. Corequisite: CS 505. Cannot be used for graduate credit towards the M.S. in Computer Science. Introduction to the concepts of iteration, asymptotic performance analysis of algorithms, recursion, recurrence relations, graphs, automata and logic, and also surveys the main data models used in computer science including trees, lists, sets, and relations. Programming assignments are given.

CS 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: students must have the approval of the co-op advisor for the CS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CS department in conjunction with the student and employer. Students must submit, for CS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CS 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Restriction: students must have the approval of the co-op advisor for the CS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CS department in conjunction with the student and employer. Students must submit, for CS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CS 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: graduate standing, and acceptance by the CS department and the Division of Career Development Services. Students must have the approval of the co-op advisor for the CS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate or graduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CS department in conjunction with the student and employer. Students must submit, for CS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CS 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CS 602. Java Programming. 3 credits, 3 contact hours.
Prerequisite: advanced Web-based programming with an emphasis on the Java language and platform. No prior knowledge of Java is required but students are expected to have a good understanding of object-oriented programming concepts such as encapsulation, inheritance, and polymorphism, experience with C++. Basic constructs and syntax and then the core advanced features. Topics include: networking and sockets, remote method invocation (RMI), database connectivity (JDBC), Java Beans, multi-threading and lighweight components (Swing). Common gateway interface (CGI) languages and browser scripting (JavaScript and VBScript) are discussed when used as a complement to the functionality of the Java language. Emphasis is on the latest version of Java, both deprecated methods and newly introduced features are discussed.

CS 608. Cryptography and Security. 3 credits, 3 contact hours.
This course involves computational methods providing secure Internet communication. Among the topics covered are: Security threats in communication systems; conventional cryptography: substitution and transposition codes; distribution of secret key over the Internet; principles of public-key cryptography; RSA and other public-key cryptographic methods; and digital signature protocol.

CS 610. Data Structures and Algorithms. 3 credits, 3 contact hours.
Prerequisite: CS 114 or CS 241 or equivalents (see undergraduate catalog for description). Intensive study of the fundamentals of data structures and algorithms. Presents the definitions, representations, processing algorithms for data structures, general design and analysis techniques for algorithms. Covers a broad variety of data structures, algorithms and their applications including linked lists, various tree organizations, hash tables, strings, storage allocation, algorithms for searching and sorting, and a selected collection of other algorithms. Programs are assigned to give students experience in algorithms, data structure design and implementation.

CS 611. Introduction to Computability and Complexity. 3 credits, 3 contact hours.
Prerequisite: CS 610. Introduces the theoretical fundamentals of computing, and provides an understanding of both the inherent capabilities and limitations of computation. The main models of computation are deterministic and non-deterministic Turing machines. Auxiliary models include partial and total recursive functions, first order logic, recursive and recursively enumerable sets, and symbol systems. Covers the essentials of computational theory: first order logic, Russel's Paradox, completeness and consistency, Goedel's Theorem, Church's Thesis, countable and uncountable sets, simulation and computation, diagonalization, dove-tailing, decidable and undecidable problems, reduction, recursion theory, Rice's Theorem, Recursion Theorem, execution time measures, P and NP, polynomial-time reduction, NP-completeness and NP-hardness and formal correctness semantics of programs.

CS 621. Numerical Analysis I. 3 credits, 3 contact hours.
Prerequisite: MATH 511 (see undergraduate catalog for description) or an introductory course in numerical methods. An introduction to computational aspects of scientific and engineering problems. Time-dependent phenomena and corresponding quantitative models. Numerical stability and conditioning. Approximation of functions. Interpolation, integration. Solution of nonlinear equations. Ordinary differential equations of the first order. Finite and iterative algorithms for solution of systems of linear equations. Emphasis on computer implementation of algorithms and application to variety of engineering problems.

CS 630. Operating System Design. 3 credits, 3 contact hours.
Prerequisites: CS 332, CS 432 (see undergraduate catalog for descriptions) and CS 505. An intensive study of computer operating system design including multiprogramming, time-sharing, real-time processing, job and task control, synchronization of concurrent processes and processors, resource scheduling, protection, and management of hierarchical storage.

CS 631. Data Management System Design. 3 credits, 3 contact hours.
Prerequisites: knowledge of C and data structures. Acquaintance with fundamental notions of relational database technology. Mathematical properties and usage of database programming languages. Methods of database design and conceptual modeling. Methods of physical storage for database information. Fundamental notions of concurrency control and recovery in database systems.

CS 632. Advanced Database System Design. 3 credits, 3 contact hours.
Prerequisites: CS 631 and good knowledge of a high-level programming language. Covers the rapidly changing concepts and principles of modern database systems and database programming based on SQL. Additional topics may include: advanced data modeling, OODBs, parallel and distributed database systems, XML and NO-SQL databases, Web-database systems, active databases, multimedia and text databases, database security, query optimization, indexing techniques, concurrency control, system performance, and data warehaousing.

CS 633. Distributed Systems. 3 credits, 3 contact hours.
Prerequisite: completion of bridge requirements. Fundamental topics concerning the design and implementation of distributed computing systems are covered, including interprocess communication, remote procedure calls, authentication, protection, distributed file systems, distributed transactions, replicated data, reliable broadcast protocols, and specifications for distributed programs. All topics will be illustrated with case studies. Optional topics may include synchronization, deadlocks, virtual time, and load balancing.

CS 634. Data Mining. 3 credits, 3 contact hours.
This course covers the principles of data mining system design and implementation. It presents methods for association and dependency analysis as well as classification, prediction, and clustering. Optional topics may include time series and graph mining, current trends in data mining, and data mining for scientific, medical and engineering applications.

CS 635. Computer Programming Languages. 3 credits, 3 contact hours.
Prerequisites: CS 505 and CS 510. The theory and design of computer language systems; the formal theory of syntax and language classification; a survey of procedure and problem-oriented computer programming languages, their syntax rules, data structures, and operations; control structures and the appropriate environments and methods of their use; a survey of translator types.

CS 636. Data Analytics with R Program. 3 credits, 3 contact hours.
Prerequisites: Entry-level courses in programming, probability and statistics (e.g. MATH333, CS280), or permission of the instructor. This course teaches data analytics with R programming. The student will learn and gain basic analytic skills via this high-level language. The course covers fundamental knowledge in R programming. Popular R packages for data science will be introduced as working examples. The course also includes case studies on data analytics projects. As a core course in data science, it provides skills that are highly desirable for both industry and academic employers.

CS 639. Elec. Medical Records: Med Terminologies and Comp. Imp.. 3 credits, 3 contact hours.
This course presents a graduate introduction to Medical Informatics for Computer Science students covering (1) the design, use and auditing of medical terminologies, such as the Unified Medical Language System (UMLS) and the Systematized Nomenclature of Medicine (SNOMED); and (2) principles of Electronic Medical Records (EMR), Electronic Health Records (EHR) and Personal Health Records (PHR), including issues of privacy and security.

CS 640. Recursive Function Theory. 3 credits, 3 contact hours.
Prerequisite: CS 540 or equivalent. Review of basic computability theory. Topics include Church's thesis; unsolvability results; creative, productive, and simple sets; computational complexity; P=NP problem; and classification of solvable problems according to their complexity.

CS 643. Cloud Computing. 3 credits, 3 contact hours.
Prerequisites: CS 633 or CS 656. This course presents a top-down view of cloud computing, from applications and administration to programming and infrastructure. Its main focus is on parallel programming techniques for cloud computing and large scale distributed systems which form the cloud infrastructure. The topics include: overview of cloud computing, cloud systems, parallel processing in the cloud, distributed storage systems, virtualization, secure distributed computing, and multicore programming.

CS 644. Introduction to Big Data. 3 credits, 3 contact hours.
Prerequisite: permission of the instructor. This course provides an in-depth coverage of various topics in big data from data generation, storage, management, transfer, to analytics, with focus on the state-of-the-art technologies, tools, architectures, and systems that constitute big-data computing solutions in high-performance networks. Real-life big-data applications and workflows in various domains (particularly in the sciences) are introduced as use cases to illustrate the development, deployment, and execution of a wide spectrum of emerging big-data solutions.

CS 645. Security and Privacy in Computer Systems. 3 credits, 3 contact hours.
Prerequisites: Students are expected to enter this course with a basic knowledge of operating systems, networking, algorithms, and data structures. Also, students should be able to program in Java and C/C++. The course covers fundamental principles of building secure systems and techniques to ensure data security and privacy. Topics include access control mechanisms, operating systems security, malicious code threats and software security, trusted computing, content protection, and database security . The course will also study existing technical approaches to protecting privacy, including Web anonymizers and ant-censorship tools, as well as policy and legal aspects of privacy.

CS 646. Network Protocols Security. 3 credits, 3 contact hours.
Prerequisites: CS 656 or ECE 637, and ability to program in Java and C/C++. This course covers the security of network protocols currently used on the internet. It seeks to familiarize students with common threats and network attacks, and provides an in-depth study of methods used to secure network communication. The course includes an applied component, which will help students gain practical experience in attacking and defending networked systems. Topics include authentication systems, and routing security, firewalls, intrusion detection, honeypots, wireless network security, malware, propagation and detection, and web security.

CS 647. Counter Hacking Techniques. 3 credits, 3 contact hours.
Prerequisites: CS 645 or CS 646 or CS 696 or ECE 638 or approval of the instructor. This course covers advanced techniques that can be used for offensive or defensive goals in network, computer systems and applications. The course follows a ?learning by doing? teaching approach through extensive use of virtual machines with vulnerable operating systems and applications. Topics covered include system memory organizations, CPU registers, assembly language fundamentals, GNU and Immunity debuggers, fuzzing based security testing development of local and remote Linux and Windows exploits, shellcode development, stealthy attacks, bypassing memory protection techniques, network and wireless hacking techniques, and ethical and legal implications of cyber-attacks.

CS 648. Cyber Sec Investigations & Law. 3 credits, 3 contact hours.
Prerequisites: CS 656 or IT 640 or permission of the instructor. This course will prepare students for a real-life experience for operating and protecting computer networks, data communication, and data storage systems. The course will provide the student with a methodology to examine and investigate intrusions and security of data storage, data management, and data transmission systems as a part of an integrated network. It will explore the various interfaces of these systems from a technical, human, and investigative perspective, and the potential legal issues. The course will provide the student with various fundamental legal knowledge necessary for a cyber practitioner: (a) basic intellectual property law including trade secrets and patents; (b) foreign viewpoints of intellectual property and compliance to include EU privacy law; (c) U.S. law of electronic surveillance, electronic search, and stored communications; (d) government and workplace consensual search and surveillance and consent banners/agreements.

CS 650. Computer Architecture. 3 credits, 3 contact hours.
Prerequisites: CS 251 (see undergraduate catalog for description) and CS 510. Exploiting instruction level parallelism (ILP) is central to designing modern computers. Presents design techniques used for such computers as IBM Power architectures, DEC Alpha, MIPS R4600, Intel P6, etc. Introduction of Instruction SET Architecture (ISA), various functional units, basic principles of pipelined computers. Modern techniques to ILP including superscalar, super-pipelining, software pipelining, loop unrolling, and VLIW. Memory hierarchy, including instruction cache, data cache, second level cache, and memory interleaving. Advanced computer architectures, including vector, array processors, interconnection technology, and ATM network of workstations. Hands-on experience designing a simple pipelined computer on screen and using CAD tools such as Cadence or ViewLogic.

CS 651. Data Communications. 3 credits, 3 contact hours.
Prerequisite: MATH 333 (see undergraduate catalog for description). Intensive study of the analytic tools required for the analysis and design of data communication systems. Topics include: birth-death queuing systems, Erlang's distribution, bulk-arrival and bulk-service systems, design and analysis of concentrators and multiplexers, elements of Renewal Theory, M/G/1 system, analysis of Time Division Multiplexing, priority queues, analysis of random access systems, time reversibility, open and closed queuing networks, mean value analysis, flow and congestion, control mechanisms, routing algorithms, flow models, and network topological design.

CS 652. Computer Networks-Architectures, Protocols and Standards. 3 credits, 3 contact hours.
Prerequisites: A high level programming language, MATH 333 (see undergraduate catalog for description), or instructor approved equivalents. Intensive study of various network architecture and protocol standards; with emphasis on the Open Systems Interconnetion (OSI) model. Topics include: analog and digital transmission, circuit and packet switching, the Integrated Services Digital Network (ISDN), Frame Relay, Broadband ISDN, Cell Relay, SONET, Local Area Networks (CSMA/CD, Token Bus, Token Ring, switched and isochronous Ethernets), Metropolitan Area Networks (FDDI, FDDI-II, DQDB), wireless and satellite networks, synchronization and error control, routing and congestion control, X.25 standard.

CS 656. Internet and Higher-Layer Protocols. 3 credits, 3 contact hours.
The course introduces the protocols and standards of the TCP/IP suite that govern the functioning of the Internet. The material covered in class is a top-down approach on introduction, discussion, and analysis of protocols from the data-link layer to the application layer. Alternative protocols to the TCP/IP suite and new protocols adopted by this suite are discussed. Numerical examples related to network planning and proocol functioning are analyzed.

CS 657. Principles of Interactive Computer Graphics. 3 credits, 3 contact hours.
Prerequisites: CS 505 or familiarity with the organization of at least one computer system, and knowledge of a structured programming language such as C. Graduate-level introduction to computer graphics concepts, algorithms, and systems. Includes 2-D raster graphics, algorithms, 2-D and 3-D geometric transformations, 3-D viewing, curves and surfaces. Emphasis on PC-based graphics programming projects. Principles of interactive graphics systems in terms of the hardware, software and mathematics required for interactive image production.

CS 659. Image Processing and Analysis. 3 credits, 3 contact hours.
Prerequisite: CS 505. Fundamentals of image processing, analysis and understanding. Topics include image representation, image data compression, image enhancement and restoration, feature extraction and shape analysis, region analysis, image sequence analysis and computer vision.

CS 660. Digital Watermarking. 3 credits, 3 contact hours.
Digital watermarking and steganography is important to ensure data security because of widely used digital multimedia and rapid growth of the Internet. Digital watermarking is a suitable tool to identify the source, creator, owner, distributor, or authorized consumer of a document or an image. Digital steganography aims at hiding digital information into covert channels, so one can conceal the information and prevent detection. This course intends to provide students an overview on different aspects of mechanisms and techniques for digital watermarking and steganography.

CS 661. Systems Simulation. 3 credits, 3 contact hours.
Prerequisites: an undergraduate or graduate course in probability theory and statistics, and working knowledge of at least one higher-level language. An introduction to the simulation of systems, with emphasis on underlying probabilistic and statistical methodologies for discrete-event simulations. Design of simulation applications, and simulation programming in a high-level language. Algorithms for the generation of pseudorandom numbers. Algorithmic methodologies for the simulation of discrete and continuous probabilistic processes. Use of statistical tools. Simulation of queuing systems. Applications of simulation to a variety of system studies. The special purpose simulation language GPSS is studied in detail.

CS 665. Algorithmic Graph Theory. 3 credits, 3 contact hours.
Prerequisite: CS 610. The elements of the theory of graphs and directed graphs with motivating examples from communication networks, data structures, etc; shortest paths, depth first search, matching algorithms, parallel algorithms, minimum spanning trees, basic complexity theory, planarity, and other topics. Programming assignments are included.

CS 666. Simulation for Finance. 3 credits, 3 contact hours.
Covers the use of Monte Carlo stochastic simulation for finance applications. Topics include generation of various random variables and stochastic processes (e.g., point processes, Brownian motion, diffusions), simulation methods for estimating quantities of interest (e.g., option prices, probabilities, expected values, quantiles), input modeling, and variance-reduction techniques. Students will write computer programs in C++. Students cannot receive credit for both CS 661 and CS/MATH 666.

CS 667. Design Techniques for Algorithms. 3 credits, 3 contact hours.
Prerequisite: CS 610. An introduction to the principles of major design techniques in algorithms. Examples from a variety of topics and problems in computer science are used to demonstrate these design techniques and their appropriate application.

CS 668. Parallel Algorithms. 3 credits, 3 contact hours.
Prerequisites: CS 610 and CS 650. This course examines a variety of parallel algorithms and architectures. Shared memory algorithms and algorithms for special architectures (tree processors, grids, systolic arrays, butterflies) are considered. The basic theory of algorithm/architecture performance will be described.

CS 670. Artificial Intelligence. 3 credits, 3 contact hours.
Prerequisite: CS 610. Fundamental concepts and general techniques in artificial intelligence. Main topics include goal tree search, logic and deduction, adduction, uncertainty, fuzzy logic, knowledge representations, machine learning, vision, and action planning. The LISP programming language is used extensively. Students are required to do programming assignments, complete a programming term project, and review case studies.

CS 673. Software Design and Production Methodology. 3 credits, 3 contact hours.
Prerequisite: CS 631. Modern techniques and methods employed in the development of large software systems, including a study of each of the major activities occurring during the lifetime of a software system, from conception to obsolescence and replacement. Topics include cost/performance evaluation, documentation requirements, system design and production techniques, system verification techniques, automated aids to system development, and project organization and management.

CS 675. Machine Learning. 3 credits, 3 contact hours.
Pre-requisites: Basic probability, linear algebra, computer programming, and graduate or undergraduate senior standing, OR approval of instructor. This course is an introduction to machine learning and contains both theory and applications. Students will get exposure to a broad range of machine learning methods and hands on practice on real data. Topics include Bayesian classification, perceptron, neural networks, logistic regression, support vector machines, decision trees, random forests, boosting, dimensionality reduction, unsupervised learning, regression, and learning new feature spaces. There will be several programming assignments, one course project, one mid-term and one final exam.

CS 676. Cognitive Computing. 3 credits, 3 contact hours.
Corequisites: CS 631. Prerequisite: Good knowledge of programming (C/C++/Java), or permission of instructor. This course provides an application oriented overview of Cognitive Computing, aimed at students specializing in data sciences. Cognitive algorithms (e.g. IBM, Stanford) that combine machine learning, data mining, AI and natural language will be used to build systems for finance, telecom and retail. Real world problems and data sets such as financial risk measurement or telecom churn will be introduced, and students will study and build Cognitive models on the IBM and open-source platforms. An important feature of this course is the usage of Harvard HBS case studies to illustrate current business challenges. This course will illustrate the development, deployment, and execution of a wide spectrum of Cognitive solutions.

CS 677. Deep Learning. 3 credits, 3 contact hours.
Prerequisites: CS 675 or approval of the instructor. This course covers current topics in data science. The topics include but are not limited to parallel programming on GPU and CPU multi-cores, deep learning, representation learning, optimization algorithms, and algorithms for big datasets. Students will present recent papers in data science, work on programming assignments, and do a machine learning/deep learning/data science project.

CS 678. Topics in Smartphone Sec & Rel. 3 credits, 3 contact hours.
This course covers current topics in the security and reliability of smartphones, and smartphone platform-based devices. The topics include but are not limited to understanding the software and hardware platforms; static and dynamic analyses for devices and apps; effective testing of devices and apps; formulating and launching attacks against these devices or apps, and understanding the security, privacy, and reliability risks that users expose themselves to when using such devices. The professor and students will present recent papers; discuss and critique papers, draw outlines for potential research explorations in this area; the students will complete a programming assignment designed to familiarize themselves with programming for the platform; the students will spend the rest of the individual work assignment on a project: running a research tool, designed to expose security and reliability issues, on popular platforms/apps/devices and reporting the findings.

CS 680. Linux Kernel Programming. 3 credits, 3 contact hours.
An in-depth study of how the Linux operating system is built from scratch. AS a hands-on course, students will perform intensive programming using Linux Kernel. The contents include machine booting, segmentation and paging memory management, creating and destroying processes, process switching and scheduling, handling exceptions and hardware interrupts, software interrupts, creating system calls, creating file systems, networking with TCP/IP, device driver writing and module programming, etc. At the end of the course, students will be able to modify Linux operating system to create their own.

CS 681. Computer Vision. 3 credits, 3 contact hours.
This course introduces computational models of computer vision and their implementation on computers, and focuses on material that is fundamental and has a broad scope of application. Topics include comtemporary developments in all mainstream areas of computer vision e.g., Image Formation, Feature Detection/Representation, Classification and Recognition, Motion Analysis, Camera Calibration, 3D/Stero Vision, Shape From X (motion, shading, texture, etc.), and typical applications such as Biometrics.

CS 683. Software Project Management. 3 credits, 3 contact hours.
This course gives the student the necessary background to allow her/him to manage software projects; this includes economic, managerial and organizational aspects. The essence of software engineering is not only to introduce a valuable software product, but to do so economically and competitively. Like any engineering discipline, software engineering depends critically on managerial, economic and organizational considerations. Students will learn software management technique, various software costing techniques including COCOMO and ROI, team organization and management, and various methods of software development including Cleanroom and Agile.

CS 684. Software Testing and Quality Assurance. 3 credits, 3 contact hours.
This course discusses software faults and techniques to reduce faults and improve software quality. Software systems are some of the most complex human artifacts ever built and also some of the most critical means to ensure our safety, well being, and prosperity. This course teaches techniques to ensure software systems perform their function correctly. Topics include software specifications, goals of testing, techniques of test data selection, test oracle design, test data analysis, test lifecycle and quality impacts of testing.

CS 685. Software Architecture. 3 credits, 3 contact hours.
The software architecture defines the structure and interactions of software modules. This course provides a working knowledge of the terms, principles and methods of software architecture and module design. It explains the constraints on the design and the properties of capacity, response time, and consistency. The "4+1" architecture model is taught with architectural styles, interface isolation, decoupling, reuse, agile design with software patterns, data structures, queuing effects, design simplification and refactoring. The non-functional requirements of reliability, performance and power consumption, component based design and good industry practices for documenting and managing the architectural process are taught.

CS 690. Software Studio. 3 credits, 3 contact hours.
Prerequisite: CS 673 or approval of the instructor. This course is the first of a two-course sequence (CS 690, CS 700B) that focuses on a team-based industrial scale software project. This two-course sequence is part of the required courses of the Master of Science in Software Engineering (MSSE). This course covers the early phases of the software lifecycle, including requirements analysis, requirements specifications, project planning, software architecture and product level design, along with associated documentation. This sequence is typically taken in the last year of the MSSE, and is intended as an opportunity for MSSE students to apply the material they have learned throughout the program.

CS 696. Network Management and Security. 3 credits, 3 contact hours.
Prerequisites: CS 652 or CS 656 or ECE 637 or ECE 683 Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and for protecting systems from network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms). Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). Same as ECE 638.

CS 698. ST:. 3 credits, 3 contact hours.

CS 700. Master'S Project. 0 credits, 0 contact hours.

CS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science. A written report must be submitted to the project advisor. The student cannot register in CS 700B more than once and the incomplete (I) grade is not allowed.

CS 701. Master's Thesis. 0 credits, 0 contact hours.

CS 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CS 704. Sequencing and Scheduling. 3 credits, 3 contact hours.
Advanced sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems are discussed in this course. Both deterministic and stochastic scheduling models are covered in detail. Heuristics and worst case analysis for "unsolvable" hard scheduling problems (NP-C problems) are introduced.

CS 708. Advanced Data Security and Privacy. 3 credits, 3 contact hours.
Prerequisites: CS 608, CS 645, CS 696, or instructor approval. In-depth study of the security and privacy issues associated with the massive amount of data that is collected, stored, shared and distributed in today's society. New paradigms are needed to address the security/privacy challenges when data is outsourced at untrusted servers (such as in cloud computing), when data is anonymized in order to be shared among untrusted parties, or when copyrighted data needs to be protected from unauthorized use.

CS 725. Independent Study in Computer Science I, II. 3 credits, 3 contact hours.
Approval of the academic advisor is required for registration. Students working on their PhD dissertation cannot register for both CS 725 and CS 726 with the same faculty. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CS 726. Independent Study II. 3 credits, 3 contact hours.
Approval of the academic advisor is required for registration. Students working on their PhD dissertation cannot register for both CS 725 and CS 726 with the same faculty. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CS 731. Applications of Database Systems. 3 credits, 3 contact hours.
Prerequisite: CS 631. Restricted to students who are specializing in computer and information systems management. Comparative study of different models of database management systems and their applications. Emphasis on the functions of the database administrator. Includes a survey of physical and logical organization of data, methods of accessing data, characteristics of different models of generalized database management systems, and case studies using these systems from various applications. Student teams design database systems for class projects.

CS 732. Advanced Machine Learning. 3 credits, 3 contact hours.
Prerequisites: CS 634 or CS 670. This course presents advanced topics in the machine learning field, with a focus on recent learning techniques developed for analysis of high dimensional data such as a model selection by regularization and ensemble learning. The course also covers the theory of supervised, semi-supervised, unsupervised, transduction and reinforcement learning, as well as applications of these learning methods.

CS 735. High Performance Analytics Dat. 3 credits, 3 contact hours.
Prerequisites: Knowledge of material from at least four courses in the following list: CS 631 (Data Management Systems Design), CS 634 (Data Mining), CS 643 (Cloud Computing), CS 644 (Introduction to Big Data), CS 675 (Machine Learning). Targeting the latest computing infrastructures and software systems for data analytics, this course introduces students to the design and analysis of scalable data science algorithms, as well as skills to implement high performance data science applications. Specific topics include in-memory data processing, column-oriented data storage and retrieval, cloud-based data intensive systems, as well as classic data analytics algorithms such as causal discovery and network inference and their scalable implementation.

CS 744. Data Mining and Management in Bioinformatics. 3 credits, 3 contact hours.
Prerequisites: CS 610 or permission of the instructor. Concepts and principles of bioinformatic data mining and management with focus on efficiency and scalability. Methods for indexing and querying biological databases, biological data mining, and algorithmic development for bimolecular and phlyogenetic data analysis. Trends and advances in areas such as functional genomics and proteomics, genetic engineering, and large-scale gene expression data analysis.

CS 750. High Performance Computing. 3 credits, 3 contact hours.
Prerequisite: CS 650. An in-depth study of the state of the art in high performance computing. Topics parallel computer architectures, programming paradigms, and their applications. Parallel architectures include PC clusters, shared-memory multiprocessors, distributed-memory multiprocessors, and multithreaded architectures. Parallel programming paradigms include message passing interface (MPI), its second-generation MPI-2, and multithreaded programming. Applications include computational science and high performance Web and database servers for Internet-based electronic commerce. Students program a parallel machine in class projects. First-hand experience in stable, scalable, high performance computing for Internet-based electronic commerce.

CS 755. Security and Privacy in Wireless Networks. 3 credits, 3 contact hours.
This course covers selected topics on security and privacy in wireless networks and is intended for graduate students who are interested in network security. This course can help the students learn the state of the art and open challenges in wireless network security and privacy, thus enhancing their potential to perform research or pursue a career in this emerging area.

CS 756. Mobile Computing and Sensor Networks. 3 credits, 3 contact hours.
This course provides an in-depth study of mobile computing and sensor networks, which are becoming major components of the transition from today's world of desktop computers to a world where computing is ubiquitous. The main topics include: techniques to handle mobility in the Internet and ad hoc networks; operating systems, programming languages, and protocols for sensor networks; applications, middleware, programming models, and security ubiquitous computing environments.

CS 759. Advanced Image Processing and Analysis. 3 credits, 3 contact hours.
Prerequisite: CS 659. Advanced study of recent research in image processing, analysis, and understanding. Topics include all image processing techniques, high-level recognition approaches, and automated expert vision systems.

CS 775. Seminar in Software Engineering. 3 credits, 3 contact hours.
Prerequisite: CS 673. A seminar in which students pursue intensive study of specialized topics in the current literature of software engineering. Each topic is supported by an initial reading list on current problems in theory and practice. The results of the studies are discussed in class with students, faculty and invited specialists.

CS 777. Seminar in Software Management and Production. 3 credits, 3 contact hours.
Prerequisites: Ph.D. core courses. A seminar in which students pursue intensive study of specialized topics in the current literature of software management and production. Each topic is supported by an initial reading list covering current problems in theory and practice. The results of the studies are discussed in class with students, faculty, and invited specialists participating. Topics include, but are not limited to, theory of algorithm structure, analysis of algorithms and programs, hardware technology assessment, automated tools for software production, software measurements and quality, peripheral device interfaces, data communications, computer networks, distributed processing, software verification, implementation standards, documentation standards, system security, software copyright, and project control and organization.

CS 782. Pattern Recognition and Applications. 3 credits, 3 contact hours.
Prerequisite: CS 610. Study of recent advances in development of (statistical and syntactic) pattern algorithm, approximation, and estimation techniques. Topics include statistical estimation theory, classifier design, parameter estimation and unsupervised learning, bias vs. variance, nonparametric techniques, linear discriminant functions, tree classifiers, feature extraction, and clustering. Additional topics include Support Vector machines (SVM), Bayesian Learning, Hidden Markov Models (HMM), evolutionary computation, neural networks, with applications to signal interpretation, time-series prediction, and Biometrics.

CS 785. Seminar in Computer and Information Science I. 3 credits, 3 contact hours.
Prerequisite: determined by nature of topic area. Advance notice of the topics to be covered is given. These seminars examine in depth a special interest area of computer and information science. It emphasizes recent work in area selected for the offering of the course. This course is for master's students and cannot apply toward master's degree credit.

CS 786. Special Topics. 3 credits, 3 contact hours.
Prerequisite: as determined by nature of topic area. A continuation of CS 785.

CS 790. Doct Dissertation & Res. 0 credits, 0 contact hours.

CS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: CS 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science. For PhD students who have successfully defended their dissertation proposal. The student must register in CS 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

CS 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CS 791. Since the CS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in computer science. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

CS 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: CS 791. Since the CS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in computer science. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

CS 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CS 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CS 790G. DOCT DISSERTATION & RES. 18 credits, 3 contact hours.

CS 791. Graduate Seminar. 0 credits, 0 contact hours.
Corequisite (for doctoral students only): CS 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in computer and information systems management. In the course students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

CS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: CS 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in computer science. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

CS 792C. Pre-Doctoral Research. 6 credits, 0 contact hours.

Big Data Essentials

Big Data embraces technology, decision-making and public policy. Supplying the technology is a fast-growing market, increasing at more than 30 percent a year and likely to reach $24 billion by 2016, according to a forecast by IDC, a research firm. Big Data is poised to be the next big trend in management.

This certificate will focus on managing Big Data analytics to understand customers, develop new products and cut operational costs. Learn how to gather and analyze large amounts of data, and how to use that data to manage and make important financial decisions.

Most of the jobs emerging in Big Data require knowledge of programming and the ability to develop applications, as well as an understanding of how to meet business needs. This certificate will provide entrepreneurs or managers the opportunity to advance in a strong new growth area, and provide consulting services to companies expanding into Big Data.

Who would be suited to take this program?

People currently working in computing who want to advance their knowledge and catch up in the growing field of Big Data. Skills most often mentioned in connection with Big Data jobs include math, statistics, data analysis, business analytics and even natural language processing.

Demand is brisk for people with data skills. The McKinsey Global Institute, the research arm of the consulting firm, projects that the United States needs 140,000 to 190,000 more workers with "deep analytical" expertise and 1.5 million more data-literate managers, whether retrained or hired, by 2020.

What are the Required Courses?

Code	Title	Credits
Core Courses		
CS 644	Introduction to Big Data	3

CS 636	Data Analytics with R Program	3
Electives		
Select two of the following:		6
CS 675	Machine Learning	
CS 670	Artificial Intelligence	
CS 732	Advanced Machine Learning	
CS 735	High Performance Analytics Dat	
MATH 661	Applied Statistics	

What Will I Learn?

Efficiency, powerful programming techniques and algorithms to transform large quantities of information into business intelligence.

In this program you'll gain 12 credits that can be applied to NJIT master's programs, and learn:

- Mathematical properties and usage of database programming languages.
- Methods of database design, conceptual modeling, and physical storage for Big Data sets.
- Fundamental notions of concurrency control and recovery in database systems.
- Goal tree search, logic and deduction, uncertainty, fuzzy logic, knowledge representations, machine learning, vision, and action planning.
- Methods for association and dependency analysis, classification and predication, and clustering analysis.
- Current trends in data mining, and data mining for scientific, medical and engineering applications.

Why Study Big Data Essentials at NJIT?

One of the nation's leading public technological universities, New Jersey Institute of Technology (NJIT) prepares students to be leaders in the technology-dependent economy of the 21st century. The university's multidisciplinary curriculum and computing-intensive approach to education provides the technological proficiency, business know-how and leadership skills that future CEOs and entrepreneurs will need to succeed. With an enrollment of almost 10,000 graduate and undergraduate students, NJIT offers small-campus intimacy with the resources of a major public research university.

The graduate certificate's narrow focus allows you to dig deep into this specific topic, and start applying your knowledge sooner. It's possible to earn the certificate entirely through online courses, so you can more easily fit it into your busy life. And whether you take courses online or on campus, you'll learn from NJIT's distinguished professors and instructors of the Department of Computer Science.

Prerequisites

An undergraduate Computer Science degree from an accredited institution is recommended. Three years or more in programming or database work.

NJIT's standard admission requirements apply to this graduate certificate.

Related Degree Programs

Credits from this graduate certificate can be applied toward the NJIT MS in Computer Science (http://cs.njit.edu/academics/graduate/mscs.php).

Take Note

Some courses have prerequisites, and must be taken in order.

Faculty Advisor: Chase Wu (http://directory.njit.edu/PersDetails.aspx?persid=chasewu)

Data Visualization

Graduate Certificate in Data Visualization

From the NJIT's Department of Informatics, the Graduate Certificate in Data Visualization allows students to develop skills in designing, developing, and applying data visualization techniques for solving real-world problems. Data visualization developers and researchers are interested in ways to communicate data to diverse users, improve analytical decision-making, and play a key role in diverse domains such as business intelligence, big data analytics, data science, scientific communication, and journalism. This certificate will equip students with both theoretical and practical knowledge for pursuing professional or research careers in data visualization.

Who would be suited to take this program?

Students and professionals interested in the broad areas of human-centered computing, urban informatics, visual analytics, business intelligence, design thinking and human-data interaction.

What are the Required and Elective Courses?

Code	Title	Credits
Required Courses (2)		6
IS 650	Data Visualization and Interpretation	
IS 657	Spatiotemporal Urban Analytics	
Elective courses (2)		6
PTC 605	Elements of Visual Design	
PTC 606	Advanced Information Design	
IS 654	Visual Informatics for Social Network and Mobile Flow	
IS 664	Customer Discovery	
IS 601	Web Systems Development	
IS 665	Data Analytics for Info System	
IS 661	User Experience Design	
Total Credits		12

What will I learn?

·***Data Visualization and Interpretation –*** Theory and practical knowledge about how to design, read, and understand visual representations of data. Hands-on knowledge about state-of the-art tools, e.g., Tableau, Python, and web-based libraries like D3.js.

·**Spatio-Temporal Urban Analytics -** Essential concepts and skills needed to efficiently develop spatiotemporal thinking. Big data analysis and visualization techniques applied to spatio-temporal urban data. Knowledge about the R programming environment.

·***Elements of Visual Design-*** theories of design, techniques of composition, and technologies of electronic and print publishing. Modules include both design principles and hands-on practice in visual literacy, layout and design, and graphic tools.

·**Advanced Information Design -** Design and creation of multimedia objects, usability heuristics, navigation theory, contemporary design practices and online community building

·**Visual Informatics for Network and Flow -** Knowledge of open source tools to visualize and interpret network and flow data. Collect network and flow data and create their own visual applications.

· ***Customer Discovery –*** User-centered design evaluation techniques for understanding potential user's practice, preferences and mental models. Knowledge of a basic set of qualitative user/customer discovery methods which is essential for both the lean startup entrepreneur and those engaged in design innovation.

·***User Experience Design –*** Process of creating compelling interaction designs for digital products from the idea stage into creating a simple and intuitive user experience blueprint. You will 'learn by doing' in a team environment, enabling you to practice the techniques with coaching from instructors.

·***Web Systems Development -*** Learn web development principles, as well as professionally relevant skills including industry standards, conventions, and procedures within large-scale programming projects.

·***Data Analytics for Information Systems -*** Learn and conduct Python, MATLAB and R based manipulation of data, along with graduate level introduction to data analysis, probability and statistics from an information systems perspective.

·**Why study Data Visualization at NJIT?**

A Mckinsey report in 2016 says: *“As data grows more complex, distilling it and bringing it to life through*

visualization is becoming critical to help make the results of data analyses digestible for decision makers. We estimate that demand for visualization grew roughly 50 percent annually from 2010 to 2015”. With the growing demand for data science-based technologies across various domains and industries, this trend will only go higher. At NJIT, we have a great opportunity to train the next generation workforce in data visualization skills and techniques that will enable them to be at the cutting edge of technological development and play crucial roles in generating actionable insights for diverse stakeholders in the data science ecosystem.

Into what industries might holders of this program find employment?

- Business Intelligence (any enterprise)

- Data Scientist
- Information Designer
- Data Visualization Developer
- Journalist

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (information design, information technology, etc.).

Related Degree Programs

All courses in this program are related to the NJIT MS in Information Systems (https://catalog.njit.edu/graduate/computing-sciences/information-systems/ms/) and MS in Professional and Technical Communication programs.

Faculty Advisors: Aritra Dasgupta (http://directory.njit.edu/PersDetails.aspx?persid=dasg018), Xinyue Ye (http://directory.njit.edu/PersDetails.aspx?persid=xye)

M.S. in Bioinformatics

Degree Requirements

A minimum of 30 credits is required for the degree, excluding bridge courses. The graduate curriculum consists of five core courses and additional elective courses, with an optional thesis (six credits) or research project (three credits).

Students with non-computing STEM background may be accepted and required to take the following bridge courses (CS 506 may count toward the credits required for the MS degree):

Code	Title	Credits
Bridge Courses		
CS 280	Programming Language Concepts	3
CS 332	Principles of Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
CS 506	Foundations of Computer Science	3
Total Credits		12

Curriculum

Code	Title	Credits
Core Courses		
BNFO 601	Foundations of Bioinformatics I	3
BNFO 602	Foundations of Bioinformatics II	3
BNFO 615	Data Analysis in Bioinformatics	3
BNFO 644	Data Mining and Management in Bioinformatics	3
MATH 663	Introduction to Biostatistics	3
Electives		
Select five of the following:		15
NJIT Electives		
BME 661	Neural Engineering	
BME 671	Biomechanics of Human Structure and Motion	
CHEM 658	Advanced Physical Chemistry	
CHEM 673	Biochemistry	
CS 631	Data Management System Design	
CS 632	Advanced Database System Design	
CS 659	Image Processing and Analysis	
CS 634	Data Mining	
CS 681	Computer Vision	
CS 731	Applications of Database Systems	
CS 782	Pattern Recognition and Applications	

IS 634	Information Retrieval	
ECE 640	Digital Signal Processing	
ECE 673	Random Signal Analysis I	
MATH 635	Analytical Computational Neuroscience	
MATH 636	Systems Computational Neuroscience	
MATH 637	Foundations of Mathematical Biology	
MATH 662	Probability Distributions	
Rutgers-Newark Electives		
R120 512	Cell Biology: Methods & Appl	
R120 515	Molecular Bio Of Eukaryotes	
R120 516	Microbial Ecology	
R120 526	Topics in Cell Biology	
R120 548	Biology Of Cancer	
R120 573	Pharmacology	
RBHS Electives		
UMD 5002		
UMD 5200		
Total Credits		30

M.S. in Computer Science

Degree Requirements

Students will meet with the graduate advisor to assist them in formulating a program of study and selecting a possible specialization.

The 30 credit requirement may be satisfied in one of three ways:

- Courses (30 credits)
- Courses (27 credits) + MS Project (3 credits)
- Courses (24 credits) + MS Thesis (6 credits)

Students with non-computing STEM background may be accepted and required to take the following bridge courses (CS 506 may count toward the credits required for the MS degree):

M.S. in Computer Science (courses only)

Code	Title	Credits
Bridge Courses		
CS 280	Programming Language Concepts	3
CS 332	Principles of Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms [1]	3
CS 506	Foundations of Computer Science [2]	3
Total Credits		12

1 CS 505 Programming, Data Structures, and Algorithms requires prior knowledge of higher level programming language. For students with no prior programming experiences, CS 113 Introduction to Computer Science and CS 114 Introduction to Computer Science II are recommended for replacement.

2 The credits earned for CS 506 Foundations of Computer Science count towards the 30 credits required for the degree.

Code	Title	Credits
Core Courses		
CS 610	Data Structures and Algorithms	3
or CS 667	Design Techniques for Algorithms	
Select three of the following:		9
CS 631	Data Management System Design	
CS 630	Operating System Design	
CS 650	Computer Architecture	

CS 656	Internet and Higher-Layer Protocols	
Elective Courses		
Two courses from an approved list of advanced courses		6
Course either from the Computer Science graduate catalog or from another department's graduate catalog [1]		3
Three courses from the Computer Science graduate catalog		9
Total Credits		30

1. Courses from outside the Computer Science Department must be relevant to the Computer Science program and require prior approval.

M.S. in Computer Science (Master's project)

Code	Title	Credits
Bridge Courses		
CS 350	Intro to Computer Systems	3
CS 332	Principles of Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms [1]	3
CS 506	Foundations of Computer Science [2]	3
Total Credits		12

1. CS 505 Programming, Data Structures, and Algorithms requires prior knowledge of higher level programming language. For students with no prior programming experiences, CS 113 Introduction to Computer Science and CS 114 Introduction to Computer Science II are recommended for replacement.
2. The credits earned for CS 506 Foundations of Computer Science count towards the 30 credits required for the degree.

Code	Title	Credits
Core Courses		
CS 610	Data Structures and Algorithms	3
or CS 667	Design Techniques for Algorithms	
Select three of the following:		9
CS 631	Data Management System Design	
CS 630	Operating System Design	
CS 650	Computer Architecture	
CS 656	Internet and Higher-Layer Protocols	
Project		
CS 700B	Master's Project	3
Elective Courses		
One course from an approved list of advanced courses		6
Course either from the Computer Science graduate catalog or from another department's graduate catalog [1]		3
Three courses from the Computer Science graduate catalog		6
Total Credits		30

1. Courses from outside the Computer Science Department must be relevant to the Computer Science program and require prior approval.

M.S. in Computer Science (Master's thesis)

Code	Title	Credits
Bridge Courses		
CS 332	Principles of Operating Systems	3
CS 350	Intro to Computer Systems	3
CS 505	Programming, Data Structures, and Algorithms [1]	3
CS 506	Foundations of Computer Science [2]	3
Total Credits		12

1 CS 505 Programming, Data Structures, and Algorithms requires prior knowledge of higher level programming language. For students with no prior programming experiences, CS 113 Introduction to Computer Science and CS 114 Introduction to Computer Science II are recommended for replacement.

2 The credits earned for CS 506 Foundations of Computer Science count towards the 30 credits required for the degree.

Code	Title	Credits
Core Courses		
CS 610	Data Structures and Algorithms	3
or CS 667	Design Techniques for Algorithms	
Select three of the following:		9
CS 631	Data Management System Design	
CS 630	Operating System Design	
CS 650	Computer Architecture	
CS 656	Internet and Higher-Layer Protocols	
Thesis		
CS 701B & 701B	Master's Thesis and Master's Thesis	6
or CS 701C	Master's Thesis	
Elective Courses		
Course either from the Computer Science graduate catalog or from another department's graduate catalog [1]		3
Three courses from the Computer Science graduate catalog		9
Total Credits		30

1 Courses from outside the Computer Science Department must be relevant to the Computer Science program and require prior approval.

2 A student must select a specialization, and the thesis must match the selected specialization.

Specializations

Students can optionally specialize in a specific area (see below) by taking a minimum of three (3) courses listed in the specialization in accordance with requirements (b) and (c). Note that some specialization courses have prerequisites that must be fulfilled before enrolling in these courses.

Computer Networking and Security

Code	Title	Credits
Select three of the following:		9
CS 608	Cryptography and Security	
CS 633	Distributed Systems	
CS 652	Computer Networks-Architectures, Protocols and Standards	
CS 696	Network Management and Security	
IS 681	Computer Security Auditing	
Total Credits		9

Databases and Data Mining

Code	Title	Credits
Select three of the following:		9
CS 632	Advanced Database System Design	
CS 731	Applications of Database Systems	
CS 634	Data Mining	
BNFO 644	Data Mining and Management in Bioinformatics	
CS 744	Data Mining and Management in Bioinformatics [1]	
CS 700B	Master's Project [1]	
Total Credits		9

1 Taking CS 700 level courses require permission of the graduate advisor.

Image Processing and Pattern Recognition

Code	Title	Credits
Select three of the following:		9
CS 659	Image Processing and Analysis	
CS 681	Computer Vision	
CS 759	Advanced Image Processing and Analysis [1]	
CS 700B	Master's Project [1]	
Total Credits		9

1 Taking CS 700 level courses require permission of the graduate advisor.

Computer Algorithms

Code	Title	Credits
CS 611	Introduction to Computability and Complexity	3
CS 667	Design Techniques for Algorithms	3
CS 700B	Master's Project	3
Total Credits		9

Bioinformatics

Code	Title	Credits
Select three of the following:		9
BNFO 601	Foundations of Bioinformatics I	
BNFO 602	Foundations of Bioinformatics II	
CS 744	Data Mining and Management in Bioinformatics [1]	
MATH 663	Introduction to Biostatistics	
CS 700B	Master's Project [1]	
Total Credits		9

1 Taking CS 700 level courses require permission of the graduate advisor.

Master's Project

Students must

- Enroll in CS 700B Master's Project.

In the semester prior to enrolling in CS 700B Master's Project, the student must prepare and submit a project proposal to the Department no later than the last weekday class day of the 8th week of the

- Fall semester for a spring project, or
- Spring semester for a summer or fall project.

The student must have an advisor in the Computer Science Department who is a tenure- track faculty member or who holds a joint appointment in the department.

Project Requirements

- Before a student pursues a Master's Project, the following requirements must be fully satisfied:
  - All bridge courses must be completed - In the semester prior to the project, a student prepares and submits a project proposal to the Department no later than the last weekday class day of the 8th week of the Fall semester for a spring project and no later than the last weekday class day of the 8th week of the Spring semester for a summer or fall project. The preparatory work for the proposal may be accomplished within the framework of a required course or an independent study course offered by the prospective advisor. Therefore, such a course must be taken in the semester prior to the project.
- A CS Department tenure-track faculty member or a faculty member who holds a joint appointment in the computer science department can advise an MS project.
- Proposal preparation must adhere to the existing departmental guidelines; the information and templates are available online.

Thesis Option

(30 credits)

Students must

- select a specialization, and
- enroll in the Thesis CS 701 Master's Thesis course for two (2) semesters (Thesis must match specialization).

A student can enroll in CS 701 Master's Thesis during the second semester of full time study. Normally the student enrolls for two semesters of CS 701 Master's Thesis to prepare the thesis proposal, perform the research, and prepare the thesis. The thesis must be orally defended and follow the style set forth by the Graduate School at NJIT. The thesis committee is composed of a Computer Science tenure-track committee chair and two other tenure-track members of the Computer Science Department or Faculty holding a joint appointment to the department.

Thesis Requirements

- Before a student pursues a Master's Thesis, the following requirements must be fully satisfied:
  - All bridge courses must be completed.
  - In the semester prior to the thesis, a student prepares and submits a thesis proposal to the department no later than week 8 of the Fall semester for a spring thesis and week 8 of the Spring semester for a summer of fall thesis. The preparatory work for the proposal may be accomplished within the framework of a required course or an independent study course offered by the prospective advisor. Therefore, such a course must be taken in the semester prior to the thesis.
- A CS department tenure-track faculty member or a faculty member who holds a joint appointment in the Computer Science Department can advise an MS thesis.
- A thesis must adhere to the style requirements set forth by the Graduate School: https://www.njit.edu/graduatestudies/thesis.php.
- An oral defense is required. The defense must take place between one week prior to the Reading Day of the semester and the last day of the Examination period. A committee of at least three tenure-track faculty members from the CS Department, including the thesis advisor, collectively determines the grade for CS 701 Master's Thesis at the conclusion of the oral defense.

Other Policies

- **Transfer:** Transfer of computer science courses from other US/Canada institutions is allowed as per university regulations provided that these courses are related to the program. Graduate Advisor and Graduate Studies Office approvals are required.
- **MS/MS Program:** Under the University MS/MS program, up to six credits of courses taken in other departments can be used for graduate credits toward the degree as long as these courses are related to computer science. Graduate advisor and Graduate Studies Office approvals are required.
- **Co-op Program:** Before a student applies for CS 590 Graduate Co-op Work Experience I/CS 591 Graduate Co-op Work Experience II/CS 592 Graduate Co-op Work Experience III registration, the successful completion of the bridge program, all ESL requirements, and at least four graduate courses is required.
- The same course cannot satisfy two or more requirements.

CS Advanced Courses

Code	Title	Credits
CS 611	Introduction to Computability and Complexity	3
CS 632	Advanced Database System Design	3
CS 643	Cloud Computing	3
CS 659	Image Processing and Analysis	3
CS 661	Systems Simulation	3
CS 667	Design Techniques for Algorithms	3
CS 670	Artificial Intelligence	3
CS 673	Software Design and Production Methodology	3
CS 680	Linux Kernel Programming	3
CS 681	Computer Vision	3
CS 696	Network Management and Security	3
CS 704	Sequencing and Scheduling	3
CS 731	Applications of Database Systems	3
CS 744	Data Mining and Management in Bioinformatics	3
CS 750	High Performance Computing	3
CS 759	Advanced Image Processing and Analysis	3
CS 782	Pattern Recognition and Applications	3

M.S. in Computing and Business

The program requires the completion of 33 credits.

Students with non-computing STEM background may be accepted and required to take the following bridge courses (CS 506 may count toward the credits required for the MS degree):

Code	Title	Credits
Bridge Courses		
CS 280	Programming Language Concepts	3
CS 332	Principles of Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
CS 506	Foundations of Computer Science	3
Total Credits		12

Code	Title	Credits
Business Core		
ACCT 615	Management Accounting	3
FIN 600	Corporate Finance I	3
HRM 601	Organizational Behavior	3
MRKT 620	Competing in Global Markets	3
Computer Science Core		
CS 610	Data Structures and Algorithms	3
CS 631	Data Management System Design	3
CS 634	Data Mining	3
CS 696	Network Management and Security	3
Electives		
Select three of the following: [1]		9
CS 632	Advanced Database System Design	
CS 652	Computer Networks-Architectures, Protocols and Standards	
CS 656	Internet and Higher-Layer Protocols	
CS 661	Systems Simulation	
ECE 644	Wireless Communication	
FIN 624	Corporate Finance II	
FIN 626	Financial Investment Institutions	
FIN 634	Mergers, Acquisitions, and Restructuring	
FIN 641	Derivatives Markets	
FIN 650	Investment Analysis and Portfolio Theory	
IS 634	Information Retrieval	
IS 681	Computer Security Auditing	
MGMT 630	Decision Analysis	
MGMT 635	Data Mining and Analysis	
MGMT 650	Knowledge Management	
MIS 625	Management Strategies for E-Commerce	
Total Credits		33

1 Only one from SOM

M.S. in Cyber Security and Privacy

Degree Requirements

An MSCSP course program must satisfy the following distribution requirement:

- 30 credits are required, which can be satisfied as either one of the following options:
  - Courses (30 credits)
  - Courses (27 credits) + MS Project (3 credits)
  - Courses (24 credits) + MS Thesis (6 credits)
- All Core courses are required.
- At most two courses can be Foundational courses.
- At most two courses can be chosen from outside the Department of Computer Science.

If a student chooses the MS project or MS thesis option, the project or thesis must be related to cyber security.

Students with non-computing STEM background may be accepted and required to take the following bridge courses (CS 506 may count toward the credits required for the MS degree):

Code	Title	Credits
Bridge Courses		
CS 280	Programming Language Concepts	3
CS 332	Principles of Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
CS 506	Foundations of Computer Science	3
Total Credits		12

M.S. in Cyber Security and Privacy (courses only)

Code	Title	Credits
Core Course Requirements		
CS 608	Cryptography and Security	3
CS 645	Security and Privacy in Computer Systems	3
CS 646	Network Protocols Security	3
CS 647	Counter Hacking Techniques	3
CS 656	Internet and Higher-Layer Protocols [1]	3
or ECE 637	Internet and Higher-Layer Protocols	
CS 696	Network Management and Security [1]	3
or ECE 638	Network Management and Security	
Electives and Foundation Courses		**12**
Electives		
CS 633	Distributed Systems	
CS 634	Data Mining	
CS 643	Cloud Computing	
CS 660	Digital Watermarking	
CS 673	Software Design and Production Methodology	
CS 678	Topics in Smartphone Sec & Rel	
CS 680	Linux Kernel Programming	
CS 684	Software Testing and Quality Assurance	
CS 708	Advanced Data Security and Privacy	
CS 755	Security and Privacy in Wireless Networks	
IS 680	Information Systems Auditing	
IS 681	Computer Security Auditing	
IS 682	Forensic Auditing for Computing Security	
IS 687	Transaction Mining and Fraud Detection	
IT 620	Wireless Networks Security and Administration	
IT 640	Network Services Administration	
ECE 636	Computer Networking Laboratory	
MGMT 688	Information Technology, Business and the Law	
MGMT 691	Legal and Ethical Issues	
Foundational Courses		

CS 610	Data Structures and Algorithms	
CS 630	Operating System Design	
CS 631	Data Management System Design	
Total Credits		30

1 Substitution allowed only for students with ECE background and with the permission of the graduate advisor.

M.S. in Cyber Security and Privacy (Master's project option)

Code	Title	Credits
Core Course Requirements		
CS 608	Cryptography and Security	3
CS 645	Security and Privacy in Computer Systems	3
CS 646	Network Protocols Security	3
CS 647	Counter Hacking Techniques	3
CS 656	Internet and Higher-Layer Protocols	3
or ECE 637	Internet and Higher-Layer Protocols	
CS 696	Network Management and Security	3
or ECE 638	Network Management and Security	
Project		
CS 700B	Master's Project [1]	3
Electives and Foundation Courses		
Electives		9
CS 633	Distributed Systems	
CS 634	Data Mining	
CS 643	Cloud Computing	
CS 660	Digital Watermarking	
CS 673	Software Design and Production Methodology	
CS 678	Topics in Smartphone Sec & Rel	
CS 680	Linux Kernel Programming	
CS 684	Software Testing and Quality Assurance	
CS 708	Advanced Data Security and Privacy	
CS 755	Security and Privacy in Wireless Networks	
IS 680	Information Systems Auditing	
IS 681	Computer Security Auditing	
IS 682	Forensic Auditing for Computing Security	
IS 687	Transaction Mining and Fraud Detection	
IT 620	Wireless Networks Security and Administration	
IT 640	Network Services Administration	
ECE 636	Computer Networking Laboratory	
MGMT 688	Information Technology, Business and the Law	
MGMT 691	Legal and Ethical Issues	
Foundational Courses		
CS 610	Data Structures and Algorithms	
CS 630	Operating System Design	
CS 631	Data Management System Design	
Total Credits		30

1 The project must be related to cyber security.

2 Substitution allowed only for students with ECE background and with the permission of the graduate advisor.

M.S. in Cyber Security and Privacy (Master's thesis option)

Code	Title	Credits
Core Course Requirements		
CS 608	Cryptography and Security	3
CS 645	Security and Privacy in Computer Systems	3
CS 646	Network Protocols Security	3
CS 647	Counter Hacking Techniques	3
CS 656	Internet and Higher-Layer Protocols [2]	3
or ECE 637	Internet and Higher-Layer Protocols	
CS 696	Network Management and Security [2]	3
or ECE 638	Network Management and Security	
Thesis		
CS 701C	Master's Thesis [1]	6
Electives and Foundation Courses		**6**
Electives		
CS 633	Distributed Systems	
CS 634	Data Mining	
CS 643	Cloud Computing	
CS 660	Digital Watermarking	
CS 673	Software Design and Production Methodology	
CS 678	Topics in Smartphone Sec & Rel	
CS 684	Software Testing and Quality Assurance	
CS 680	Linux Kernel Programming	
CS 708	Advanced Data Security and Privacy	
CS 755	Security and Privacy in Wireless Networks	
IS 680	Information Systems Auditing	
IS 681	Computer Security Auditing	
IS 682	Forensic Auditing for Computing Security	
IS 687	Transaction Mining and Fraud Detection	
IT 620	Wireless Networks Security and Administration	
IT 640	Network Services Administration	
ECE 636	Computer Networking Laboratory	
MGMT 688	Information Technology, Business and the Law	
MGMT 691	Legal and Ethical Issues	
Foundational Courses		
CS 610	Data Structures and Algorithms	
CS 630	Operating System Design	
CS 631	Data Management System Design	
Total Credits		30

[1] The thesis must be related to cyber security.

[2] Substitution allowed only for students with ECE background and with the permission of the graduate advisor.

Master of Science in Cyber Security and Privacy (CSP) - Cyber Defense Option

The objective of the Cyber Defense Professional Science Master (PSM), an option of the MS CSP, is to create leaders with strong communication and management skills in addition to the strong technical knowledge in security and privacy of computer systems, networks and web applications. This PSM is designed for working professionals or students who already have acquired some professional experience. The Cyber Defense PSM is affiliated with the PSM National Office.

A student in the MS CSP – Cyber Defense Option must satisfy the following distribution of requirements:

- 36 credits are required.
- All Cybersecurity Core courses are required (21 credits)

- The rest of 15 credits must be taken from the combined list of PTC (Professional and Technical Communications), Management, and Computing electives, with at least 3 credits, and no more than 6, from each of the 3 elective lists

Among the required Cybersecurity Core courses, the program includes an MS Project, YWCC 691. These projects are part of a project course, supervised by a CS faculty member, and done in collaboration with industrial partners. These partners will propose projects, and they will co-supervise the students together with the instructor of the course. Students who have a job are allowed to work on projects from their companies, in which case their employer will be actively engaged in the project supervision. The projects will generally be done in teams of 3 students.

Code	Title	Credits
Core Course Requirements:		
CS 608	Cryptography and Security	3
CS 645	Security and Privacy in Computer Systems	3
CS 646	Network Protocols Security	3
CS 647	Counter Hacking Techniques	3
CS 656	Internet and Higher-Layer Protocols	3
CS 696	Network Management and Security	3
YWCC 691	Graduate Capstone Project	3
PTC (Professional and Technical Communications) Courses		**6**
PTC 601	Advanced Professional and Technical Communication	
PTC 620	Proposal Writing	
PTC 622	Working in Teams: Collaborative and Interpersonal Communications	
PTC 624	Professional and Technical Editing	
PTC 628	Analyzing Social Networks	
PTC 629	Theory and Practice of Social Media	
PTC 632	Content Management and Information Architecture	
Management Courses		**6**
Select two of the following:		
ACCT 615	Management Accounting	
EM 636	Project Management	
FIN 600	Corporate Finance I	
MGMT 641	Global Project Management	
MGMT 650	Knowledge Management	
MGMT 682	Business Research Methods I	
MGMT 688	Information Technology, Business and the Law	
MGMT 691	Legal and Ethical Issues	
Cybersecurity Elective Courses		**6**
CS 610	Data Structures and Algorithms	
CS 630	Operating System Design	
CS 631	Data Management System Design	
CS 632	Advanced Database System Design	
CS 634	Data Mining	
CS 643	Cloud Computing	
CS 660	Digital Watermarking	
CS 673	Software Design and Production Methodology	
CS 700B	Master's Project	
CS 708	Advanced Data Security and Privacy	
CS 678	Topics in Smartphone Sec & Rel	
CS 684	Software Testing and Quality Assurance	
CS 708	Advanced Data Security and Privacy	
CS 755	Security and Privacy in Wireless Networks	
IS 680	Information Systems Auditing	
IS 681	Computer Security Auditing	
IS 682	Forensic Auditing for Computing Security	
IT 620	Wireless Networks Security and Administration	

IT 640	Network Services Administration
ECE 636	Computer Networking Laboratory

M.S. in Data Science

Degree Requirements

Students in the Master of Science in Data Science (MSDS) program must successfully complete 30 credits based on any of the following options:

- Courses (30 credits)
- Courses (27 credits) + MS Project (3 credits)
- Courses (24 credits) + MS Thesis (6 credits)

Independent of the chosen option, all core courses in the respective tracks are required.

At most two courses can be chosen from outside the respective track with approval of the respective Program Co-Directors. Computational track students are allowed at most three electives that are non-Computer Science courses. Statistics track students are allowed at most three electives that are non-Math courses.

If a student chooses the MS project or MS thesis option, the project or thesis must be related to data science and requires approval from one of the Program Co-Directors.

The MSDS program has computational and statistics tracks that students must choose from at admission time. These tracks have different core courses but share the same admission requirements and electives.

Students may choose an elective outside the list after approval of their respective advisor.

M.S. in Data Science

Code	Title	Credits
Core Course Requirements for Computational Track		
CS 675	Machine Learning	3
CS 644	Introduction to Big Data	3
CS 636	Data Analytics with R Program	3
CS 677	Deep Learning (Deep Learning)	3
MATH 661	Applied Statistics	3
Core Course Requirements for Statistics Track		
MATH 660	Introduction to statistical Computing with SAS and R	3
MATH 661	Applied Statistics	3
MATH 678	Stat Methods in Data Science	3
CS 644	Introduction to Big Data	3
CS 675	Machine Learning	3
or MATH 680	Advanced Statistical Learning	

Code	Title	Credits
Electives and Foundation Courses		**15**
Computer Science Electives		
CS 610	Data Structures and Algorithms	3
CS 631	Data Management System Design	3
CS 632	Advanced Database System Design	3
CS 634	Data Mining	3
CS 636	Data Analytics with R Program (only available to students in the Math core)	3
CS 639	Elec. Medical Records: Med Terminologies and Comp. Imp.	3
CS 643	Cloud Computing	3
CS 645	Security and Privacy in Computer Systems	3
CS 656	Internet and Higher-Layer Protocols	3
CS 659	Image Processing and Analysis	3
CS 661	Systems Simulation	3

CS 670	Artificial Intelligence	3
CS 676	Cognitive Computing	3
CS 677	Deep Learning (Deep Learning(available only to students in statistics track))	3
CS 683	Software Project Management	3
CS 684	Software Testing and Quality Assurance	3
CS 681	Computer Vision	3
CS 708	Advanced Data Security and Privacy	3
CS 731	Applications of Database Systems	3
CS 732	Advanced Machine Learning	3
CS 735	High Performance Analytics Dat	3
CS 744	Data Mining and Management in Bioinformatics	3
CS 782	Pattern Recognition and Applications	3
Math Electives		
MATH 630	Linear Algebra and Applications	3
MATH 631	Linear Algebra	3
MATH 644	Regression Analysis Methods	3
MATH 660	Introduction to statistical Computing with SAS and R (only available to students in computational track)	3
MATH 662	Probability Distributions (only available to students in computational track)	3
MATH 664	Methods for Statistical Consulting	3
MATH 665	Statistical Inference (only available to students in computational track)	3
MATH 678	Stat Methods in Data Science	3
CS 680	Linux Kernel Programming	3
CS 683	Software Project Management	3
MATH 699	Design and Analysis of Experiments	3
MATH 717	Inverse Problems and Global Optimization	3
MATH 786	Large Sample Theory and Inference	3
MATH 787	Non-Parametric Statistics	3
Other Electives		
BIOL 638	Computational Ecology	3
BME 698	Selected Topics	3
MGMT 635	Data Mining and Analysis	3
MGMT 630	Decision Analysis	3
FIN 600	Corporate Finance I	3
FIN 641	Derivatives Markets	3
FIN 642	Derivatives and Structured Finance	3
MRKT 630	Models Of Consumer Behavior	3
IS 631	Enterprise Database Management	3
IS 665	Data Analytics for Info System	3
IS 687	Transaction Mining and Fraud Detection	3
IS 688	Web Mining	3
BNFO 601	Foundations of Bioinformatics I	3
BNFO 602	Foundations of Bioinformatics II	3
BNFO 615	Data Analysis in Bioinformatics	3
BNFO 620	Genomic Data Analysis	3
Total Credits		**30**

Recommended course sequence M.S. in Data Science for Computational Track

	Fall	**Spring**
Year 1	CS 675 Machine Learning	CS 631 Data Management and System Design
	MATH 661 Applied Statistics	CS 644 Big Data
	CS 636 R for Data Science	CS 677 Deep Learning
Year 2	Free elective or Master thesis course	Free elective or Masters thesis course

	Free elective or Master project course
	Free elective

Recommended course sequence for M.S. in Data Science for Statistics Track

	Fall	Spring
Year 1	MATH 660 Intro to Statistical Computing with R and SAS	MATH 678 Statistical Methods in Data Science
	MATH 661 Applied Statistics	CS 644 Big Data
	Free Elective	MATH 630 Linear Algebra and Applications
Year 2	CS 675 Machine Learning or MATH 680 Advanced Statistical Learning	Free elective or Masters thesis course
	Free elective or Master thesis for thesis	
	Free elective or Master project course	

M.S. in Software Engineering

The program requires the completion of 33 credits.

Students with non-computing STEM background may be accepted and required to take the following bridge courses (CS 506 may count toward the credits required for the MS degree):

Code	Title	Credits
Bridge Courses		
CS 280	Programming Language Concepts	3
CS 332	Principles of Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
CS 506	Foundations of Computer Science	3
Total Credits		12

[1] Students can take other CS courses with advisor approval

Code	Title	Credits
Required Courses (21 Credits) Students must take a two-course sequence (CS 690 in the Fall followed by CS 700B in the following Spring) that focuses on a team-based industrial scale software project.		
CS 684	Software Testing and Quality Assurance [1]	3
CS 685	Software Architecture [1]	3
CS 683	Software Project Management [1]	3
IS 676	Requirement Engineering	3
CS 673	Software Design and Production Methodology [1]	3
CS 690	Software Studio	3
CS 700B	Master's Project	3
Elective Courses		
Select four of the following:		12
CS 602	Java Programming	
CS 630	Operating System Design [1]	
CS 631	Data Management System Design [1]	
CS 632	Advanced Database System Design	
CS 633	Distributed Systems [1]	
CS 634	Data Mining	
CS 635	Computer Programming Languages	
CS 652	Computer Networks-Architectures, Protocols and Standards [1]	
CS 656	Internet and Higher-Layer Protocols [1]	
CS 659	Image Processing and Analysis	
CS 670	Artificial Intelligence	
CS 675	Machine Learning	
CS 696	Network Management and Security [1]	

IS 690	Web Services and Middleware	
IS 663	System Analysis and Design	
EM 636	Project Management	
EM 637	Project Control	
MGMT 620	Management of Technology	
Total Credits		33

[1] Students can take other CS courses with advisor approval

Ph.D. in Computer Science

Course Requirements

For students entering the program with a Master's degree in Computer Science or related areas, 12-24 credits at the 600 and 700 level (at least 12 credits at the 700 level). The default requirement is 24 credits, but waivers for 600 level courses may be determined in consultation with and written approval by the PhD committee based on the student's prior background in the four areas of the qualifying examinations. At most 6 credits can be Independent Study in Computer Science (CS 725 and/or CS 726). If a student takes two Independent Study courses, then they should be done with two different professors.

For students entering the program without a Master's degree in Computer Science or related areas, 36 credits at the 600 and 700 level. At least 12 credits must be at the 700 level, and out of those at most 6 credits can be Independent Study in Computer Science (CS 725 and/or CS 726). If a student takes two Independent Studies, then they should be done with two different professors.

Doctoral Dissertation Credits

For students who were admitted in the program in the Fall 2015 semester or after, the rules are described at: http://www5.njit.edu/graduatestudies/content/new-phd-credit-requirements/

For students who were admitted in the program before the Fall 2015 semester, students must complete 30 credits of CS 790. A maximum of 6 credits of CS 792 Pre-Doctoral Research may be used toward the CS 790 requirement.

CS 791: Doctoral Seminar

For students who were admitted in the program in the Fall 2015 semester or after, the rules are described at: http://www5.njit.edu/graduatestudies/content/new-phd-credit-requirements/

For students who were admitted in the program before the Fall 2015 semester, students must complete 30 credits of CS 790. A maximum of 6 credits of CS 792 Pre-Doctoral Research may be used toward the CS 790 requirement.

CS 791: Doctoral Seminar

Full-time students are required to enroll in CS 791 every semester. *Full-time PhD students are required to attend 2/3 of the weekly Wednesday departmental seminars.*

Qualifying Examinations

All PhD students are required to take qualifying examinations in four areas.

Code	Title	Credits
Two examinations are in the following two areas:		
CS 610	Data Structures and Algorithms	3
CS 611	Introduction to Computability and Complexity	3

Code	Title	Credits
Two examinations are in the following areas:		
CS 630	Operating System Design	3
CS 631	Data Management System Design	3
CS 634	Data Mining	3
CS 650	Computer Architecture	3
CS 656	Internet and Higher-Layer Protocols	3
CS 659	Image Processing and Analysis	3

CS 661	Systems Simulation	3
CS 670	Artificial Intelligence	3
CS 675	Machine Learning	3
BNFO 601	Foundations of Bioinformatics I	3
or BNFO 602	Foundations of Bioinformatics II	

PhD students are allowed to take five qualifying examinations and are required to pass at least four out of the five (CS 610 and CS 611 must be among the four courses the students pass). If they fall short of the four examinations on the first year, then they must make up the number of missing examinations the second year and may take one more examination than the number they are required to pass.

Informatics

The Department of Informatics consists of two divisions: Information Systems and Information Technology. All Informatics degree programs are STEM degrees (STEM = Science, Technology, Engineering and Math).

The Division of Information Systems (IS) demonstrates a long history of integrating innovation, research and education at the intersection of people, information and computing technology. Our state-of-the-art curriculum, with a hands-on focus in web, social media, data science, business applications, and user experience, provides students with solid career knowledge, design and implementation skills, and leadership preparation. Students at all levels engage in research alongside distinguished professors, creating, applying and disseminating fundamental knowledge and innovative approaches. Research concentrates in two rigorous tracks -- data-intensive research and human-centered computing -- conducted by faculty who win teaching awards, highly competitive grants, best paper awards, write books, and publish extensively in very selective journals.

Information Technology (IT) is the "practitioner focused" discipline within the field of computing. The BS IT degree program, the applied computing degree at NJIT, provides a balanced approach to software and hardware applications and their conceptual underpinnings. Moreover, the program offers an array of specializations that prepare students to enter various areas of the information economy. IT courses are taught by faculty and industry professionals having years of IT experience. Students benefit from a hands-on approach that provides them with a real grasp of the actual technology, development tools, and paradigms in demand in the IT industry.

NJIT Faculty

B

Bieber, Michael P., Professor Emeritus

D

Deek, Fadi P., Distinguished Professor, Provost and Senior Executive Vice President

Deek, Maura, Senior University Lecturer

E

Egan, Richard W., Senior University Lecturer

H

Halper, Michael, Professor and IT Program Director

Hendela, Arthur, Professor of Practice

Hiltz, S. Roxanne, Distinguished Professor Emeritus

Hoover, Amy, Assistant Professor

J

Jones, Quentin, Associate Professor

K

Kehoe, Donald, University Lecturer

Kettering, Joan, Senior University Lecturer

L

Lee, Michael, Assistant Professor

Lin, Lin, Senior University Lecturer

N

Nersesian, Eric, University Lecturer

P

Phan, Hai, Assistant Professor

S

Scher, Julian M., Associate Professor Emeritus

Senesy, Stanley, Senior University Lecturer

Sequeira, Marc, University Lecturer

Statica, Robert, Senior University Lecturer

T

Tremaine, Marilyn M., Professor Emeritus

Turoff, Murray, Distinguished Professor Emeritus

W

Wang, Shaohua, Assistant Professor

Waltrous-Deversterre, Lori, Senior University Lecturer

Williams, Keith A., University Lecturer

Wong, Donghee Yvette, Assistant Professor

Wu, Yi-Fang, Brook, Associate Professor and Chair

X

Xu, Songhua, Assistant Professor

Programs

- Business and Information Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-ms/)
- Information Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/ms/)
- Information Technology and Administration Security - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/administration-security-ms/)

Programs

- Information Systems - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/phd/)

Programs

- Business and Information Systems Implementation (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-cert/)
- Data Mining (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/data-mining-cert/)
- IT Administration (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-technology/it-administration-cert/)
- Information Security (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/information-security-cert/)
- Network Security and Information Assurance (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/network-security-information-systems-cert/)

- Software Engineering, Analysis, and Design (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/software-engr-analysis-design-cert/)
- Web Systems Development (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/web-systems-development-cert/)

Informatics Courses

IS 513. Programming Foundations for IS. 3 credits, 3 contact hours.
This course is an introduction to the Java programming language teaching the foundations of writing, testing and debugging of programs. The course has three major parts. The first part teaches fundamental programming techniques that use primitive data types, variables, assignments expressions and operators, control statements, arrays and files I/O. The second part covers testing and debugging, and teaches students how to write programs that work reliably. The third part introduces object-oriented programming.

IS 531. Database Fundamentals. 3 credits, 3 contact hours.
This course gives students extensive, pragmatic experience in designing, building, querying, updating, maintaining and managing relational databases, using the Structured Query Language (SQL). We will start our journey by analyzing what database is and why it is superior to other data management methods. We will then conduct logical and physical database design. SQL will be extensively covered, and students will design and implement sophisticated SQL queries invoking self-joins, outer joins, correlated subqueries and related concepts. Hands-on experience will be gained by working with actual databases using industry-standard database management systems such as Oracle.

IS 565. Aspects Of Information Systems. 3 credits, 3 contact hours.
Methods and models of supporting the management process; ethical issues pertaining to the construction, deployment, and impact of information systems on organizations and society; description, analysis, and design of information systems to assist problem solving and decision-making in a business environment.

IS 590. Graduate Co-op Work Experience I. 3 credits, 3 contact hours.
Prerequisite: students must have the approval of the co-op advisor for the IS department. Provides on-the-job reinforcement and application of concepts presented in the graduate IS curriculum. Work assignments are identified by the co-op office and developed and approved by the IS department in conjunction with the student and employer. Students must submit, for IS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in IS.

IS 591. Graduate Co-op Work Experience II. 3 credits, 3 contact hours.
Prerequisite: students must have the approval of the co-op advisor for the IS department. Provides on-the-job reinforcement and application of concepts presented in the graduate IS curriculum. Work assignments are identified by the co-op office and developed and approved by the IS department in conjunction with the student and employer. Students must submit, for IS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in IS.

IS 592. Graduate Co-op Work Experience III. 3 credits, 3 contact hours.
Prerequisites: graduate standing, and acceptance by the IS department and the Division of Career Development Services. Students must have the approval of the co-op advisor for the IS department. Provides on-the-job reinforcement and application of concepts presented in the graduate IS curriculum. Work assignments are identified by the co-op office and developed and approved by the IS department in conjunction with the student and employer. Students must submit, for IS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in IS.

IS 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisites: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

IS 601. Web Systems Development. 3 credits, 3 contact hours.
Prerequisites:NONE Students will gain experience in open source web development through an intensive hands-on project, applying real-world problem-solving skills to meeting information systems requirements. Students will learn Web development principles, as well as professionally relevant skills including industry standards, conventions, and procedures within large-scale programming projects. Also covered are the communication tools, technologies, and practices that individuals use to coordinate and collaborate within the open source software development community.

IS 612. Emergency Management Informatics. 3 credits, 3 contact hours.
This course covers core aspects of Emergency Management (EM) as they relate to information systems and usage of associated technologies. EM theory identifies four critical areas: 1) understanding & mitigating risk, 2) planning & preparedness, 3) reaction & response, 4) recovery & normalization. The role of informatics for each critical area will vary and is the basis for discussions and assignments. This course also focuses on innovative information systems approaches to EM in each area. Within the EM domain, business continuity (information processing and sharing during crisis situations), cyberterrorism, and international response are covered.

IS 613. Design of Emergency Management Information Systems. 3 credits, 0 contact hours.
This course is concerned with the development of requirements, the design of the human interaction, and the supporting functionality of any Information System related to the complete preparedness lifecycle for emergency, disaster, and crisis situations for government bodies, non-profit, and/or private organizations that are concerned with business continuity. It also focuses on organizational behavior and its effects on the functionality of the system and the design of the human interface.

IS 614. Command and Control Systems. 3 credits, 3 contact hours.
This course investigates the relevance and applicability of using of Command and Control (C2) models in organizational responses to both normal emergencies and catastrophic events. C2 refers to how leadership, authority, decision-making and coordination are assured within an organization, including distributed and virtual organizations. The course examines the functionality and properties of C2 systems in terms of matching requirements for these systems to the behavior of individuals, groups, and organizations during emergency conditions. It will address integrating systems and technologies within organizational emergency operations functions and processes to include business continuity and disaster response.

IS 616. Learning Methodologies and Training Technologies. 3 credits, 3 contact hours.
This course provides an overview of learning methodologies and training technologies, with an emphasis on emergency management. It reviews theories and develops skills for the planning, evaluation and selection of traditional and new technology-driven learning and training methods. Course participants will review relevant research and learn how to choose the most effective training methodologies, technologies and content resources appropriate to the needs of different audiences.

IS 631. Enterprise Database Management. 3 credits, 3 contact hours.
Prerequisites: IS 601 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20601) This course provides an understanding of the issues as well as hands-on experience in managing database systems as an essential organizational resource. Students will obtain a conceptual foundation of database design and explore the implications for organizational database usage. Students also will gain experience with enterprise database management systems, such as Oracle. This course introduces the design and management of enterprise-wide database systems. Topics include: (1) data modeling and database design; (2) database implementation with SQL; (3) database access standards for enterprise database systems; (4) multidimensional databases, online analytic processing (OLAP) and data warehousing, customer relationship management (CRM); and (5) web-based enterprise database systems.

IS 634. Information Retrieval. 3 credits, 3 contact hours.
Prerequisites: IS 601 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20601) Modern information retrieval systems, such as web search engines, empower users to easily access information on the web. The course covers the concepts and principles of information retrieval systems design, including web crawling, automatic indexing, vector space modeling, retrieval algorithms, digital libraries, text mining, information extraction, and document warehousing. These techniques are essential for building web systems, text databases, document processing systems, and other advanced information management systems.

IS 661. User Experience Design. 3 credits, 3 contact hours.
This is a foundation course on the design of digital products. User eXperience Design (UXD) isn't just about making interfaces usable. It is about designing and building relevant and successful products. Effective UXD requires a mix of Interaction Design (ID) methods and processes. This course takes you through the process of creating compelling interaction designs for digital products from the idea stage into creating a simple and intuitive user experience blueprint. You will 'learn by doing' in a team environment, enabling you to practice the techniques with coaching from instructors. The course will demystify Lean UX; Agile UX; Human Computer Interaction (HCI); Design Audits and Claims analysis; Persona construction; Storyboarding; ID scenarios; ID Frameworks; Role of user-research in UXD; and Design Patterns.

IS 663. System Analysis and Design. 3 credits, 3 contact hours.
Pre or Corequisite: IS 601 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20601) This course develops the skills necessary to analyze, design and manage the development of effective enterprise-scale information systems solutions incorporating contemporary methods and effective organizational and global project management practices. It focuses on technical business systems analysis and design techniques, and covers key software engineering principles, methods and frameworks, including process models, agile and lean principles, project and risk management, estimation, requirements elicitation and analysis, modeling, system and software architecture, design patterns, and quality systems. Students will actively participate in discussions, review selected articles, participate in team exercises and collaborate on projects involving analysis and prototyping of applications addressing real-world problems and integrating current and emerging technologies.

IS 664. Customer Discovery. 3 credits, 3 contact hours.
'Customer Discovery' is the term used by lean startup companies to describe the process of directly engaging with customers to explore potential new markets. Such evidence-based entrepreneurship guides the potential for new product ideas early in the development process. Similarly, high-tech innovators in new media, web, software apps, social networking, wearable computing, and mobile devices need to determine early on if their proposed solutions address real user needs. They do this by understanding potential user's practice, preferences and mental models. As a result, knowledge of a basic set of qualitative customer discovery methods is essential for both the lean startup entrepreneur and those engaged in interaction design innovation. This course teaches these methods through hands-on team projects. Students will design and run interview and diary studies, thinking out-loud protocols and focus groups, and analyze and report on findings. Students will explore over the course of the semester a problem domain and gain understanding of customer needs that will serve as a foundation for high-tech, innovative product design.

IS 665. Data Analytics for Info System. 3 credits, 3 contact hours.
Prerequisites: IS 601 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20601) This course gives a graduate level introduction to data analysis, probability and statistics from an information systems perspective, including many of the techniques that are most relevant to the profession of Data Scientist for business, data and web analytics, as well as current data sets. We will learn and conduct Python, matlab and R based manipulation of data. Course topics include the rudiments of probability and random variables, estimation, special distribution and sampling, Markov processes, hypothesis testing, graphics and visualization.

IS 676. Requirements Engineering. 3 credits, 3 contact hours.
Corequisites: IS 663 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20663) or CS 673 (http://catalog.njit.edu/archive/2019-2020/search/?P=CS%20673) or equivalent project experience in the field. Requirements engineering is one of the all-important beginning stages of the systems development life cycle. Revealing and understanding the system's requirements is a crucial component of success for developing new computing systems or adjusting existing applications. This course covers the theory, principles, and practical application of the methodologies and tools for requirements engineering. The focus is development of large software systems and the integration of multiple systems into a comprehensive, domain dependent solution. All aspects of requirements engineering including the knowledge and skills needed to elicit and analyze requirements, translate these requirements into technical specifications, verify that the requirements accurately capture the system requirements, and manage software requirements through the system development cycle will be covered. Students will actively participate in discussions, labs and exercises, and prepare operational requirements and technical specifications for real-world problems. We will spend a considerable amount of time interacting and learning through discussion of assigned readings and other material.

IS 677. Information System Principles. 3 credits, 3 contact hours.
This course introduces the field of Information Systems; the study of how people and organizations should use information technologies effectively. We examine the major areas in the field, analyzing the major issues, trends and problems. We survey the role of information systems in organizations and how these systems support organizational objectives and organizational structure, as well as providing competitive business advantages. We discuss basic concepts such as the systems point of view, the organization of a system, the nature of information and information flows, as well as how people process information and related cognitive concepts. We also examine various types of information system applications such as e-commerce, supply chain, decision support, and enterprise systems. And, finally, we also consider critical ethics issues including privacy, personalization and security.

IS 678. IT Service Management. 3 credits, 3 contact hours.
Prerequisites: IS 663 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20663) or CS 673 (http://catalog.njit.edu/archive/2019-2020/search/?P=CS%20673) This course introduces the Information Technology Infrastructure Library (ITIL) fundamentals of the service management life cycle-service strategy, service design, service transition, service operation, and continual service improvement. ITIL provides a comprehensive, consistent, and coherent framework of best practices for IT Service Management (ITSM), which promotes a quality approach for achieving business effectiveness and efficiency in the use of information systems. This course presents the basic terminology and an overview of the functions and processes for each of the life cycle phases as they apply to IT Management. Although ITIL is originally presented as an approach for designing IT processes, we can expand this view and apply it to the design of other business services. Possible semester-long contexts are the processes of an educational services provider or health care services provider.

IS 680. Information Systems Auditing. 3 credits, 3 contact hours.
Due to the dynamic nature of information technology, the need arises continually to redefine audit, control and security requirements and processes. Topics include the IS audit process, IT infrastructure and operations, information protection, disaster recovery and business continuity, IT service delivery and support, business application systems, and project management. Students gain practical experience with each by working through a series of sample Certified Information Systems Audit (CISA) exam questions.

IS 681. Computer Security Auditing. 3 credits, 3 contact hours.
This course reflects the current emphasis on information security and security management in Fortune 500 corporations. Students will delve into information protection concepts, privacy impact analysis, computer crime, legal issues, controls and auditing systems, and firewall configuration. Students will have the opportunity to learn and perform evaluations on security infrastructures in a controlled environment in class labs by completing realistic security auditing projects and using vulnerability assessment tools to assess risks and evaluate security controls on networked infrastructures.

IS 682. Forensic Auditing for Computing Security. 3 credits, 3 contact hours.
A computer forensics audit is the proper identification and collection of computer evidence. Computers are involved in security violations through crime or violations of policy, or being targeted by an attack. This course deals with the preservation, identification, extraction, documentation, reporting, acquisition, analysis and interpretation of computer data. Topics covered include evidence handling, chain of custody, collection, preservation, identification and recovery of computer data. In this hands-on course, you will conduct several labs where you will be taught to analyze, review and extract information from computer hard drives, and determine what and how the information could have been compromised. Computer Forensics Audit professionals become experts in e-discovery and preserving sensitive evidential matter.

IS 683. Web Systems Development. 3 credits, 3 contact hours.
Students will gain experience in open source web development through an intensive hands-on project, applying real-world problem-solving skills to meeting information systems requirements. Students will learn Web development principles, as well as professionally relevant skills including industry standards, conventions, and procedures within large-scale programming projects. Also covered are the communication tools, technologies, and practices that individuals use to coordinate and collaborate within the open source software development community.

IS 684. Business Process Innovation. 3 credits, 3 contact hours.

Prerequisites: IS 663 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20663) or CS 673 (http://catalog.njit.edu/archive/2019-2020/search/?P=CS%20673) This course adopts a balanced approach to business process innovation (BPI) that includes both incremental improvement and re-engineering. It specifically examines the concept of a service-oriented architecture (SOA) and the use of web services as a way to enable scalable and adaptive business processes. Students will learn how to develop process maps using the Business Process Modeling Notation (BPMN) and design process improvements to achieve efficiency, effectiveness, compliance and agility objectives. The focus of the course is on ways in which information technology can be used to manage, transform and improve business processes.

IS 685. Enterprise Architecture and Integration. 3 credits, 3 contact hours.

Prerequisites: None, but recommend completion of IS 663 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20663) or CS 673 (http://catalog.njit.edu/archive/2019-2020/search/?P=CS%20673). The Enterprise Architecture (EA) describes an organization's IT strategy and operational structure. IS and IT professionals utilize the EA to analyze, design and integrate the (often heterogeneous) IT infrastructure and applications to most effectively support the enterprise and respond to risks. Students learn to develop an EA analysis which reflects its business strategies, capabilities, processes, and systems, metrics, information resources, and networking infrastructure. This enables students to determine the impact of IT solutions, by learning to deconstruct, analyze and configure IT systems in alignment with enterprise-wide business strategies. The course covers the industry standard The Open Group Architecture Framework (TOGAF) enterprise architecture framework and focuses on Enterprise Application Integration (EAI).

IS 686. Pervasive Computing: An HCI Perspective. 3 credits, 3 contact hours.

This course examines Pervasive/Ubiquitous Computing, the trend toward increasingly ubiquitous connected computing devices in the environment - a trend being brought about by a convergence of advanced electronic, and particularly, wireless technologies and the internet. We do this from a Human Computer Interaction perspective looking at the current and future design of various systems.

IS 687. Transaction Mining and Fraud Detection. 3 credits, 3 contact hours.

Prerequisites: IS 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20665) Increasingly, all of our transactions are electronic. We use debit and credit cards (electronic transactions) instead of checks and cash at banks, restaurants, stores, and many other businesses. Evaluation of transactions to find risk includes detection of terrorists and money launderers. Every financial institution is legally required to monitor transactions to detect organized crime and terrorism. Mining transaction streams to find good or bad customers in a rapidly growing area of employment for IS graduates. This course will present methods that are being used to analyze and mine transactional data and the business applications of these methods.

IS 688. Web Mining. 3 credits, 3 contact hours.

Prerequisite: IS 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20665). Web mining aims to discover useful information and knowledge from the Web hyperlink structure, page contents and usage logs. It has direct applications in e-commerce, Web analytics, information retrieval/filtering, personalization, and recommender systems. Employees knowledgeable about Web mining techniques and their applications are highly sought by major Web companies such as Google, Amazon, Yahoo, MSN and others who need to understand user behavior and utilize discovered patterns from terabytes of user profile data to design more intelligent applications. The primary focus of this course is on Web usage mining and its applications to business intelligence and biomedical domains. We learn techniques from machine learning, data mining, text mining, and databases to extract useful knowledge from the Web and other unstructured/semistructured, hypertextual, distributed information repositories. This data could be used for site management, automatic personalization, recommendation, and user profiling. Topics covered include crawling, indexing, ranking and filtering algorithms using text and link analysis, applications to search, classification, tracking, monitoring, and Web intelligence. Programming assignments give hands-on experience. A group project highlights class topics.

IS 690. Web Services and Middleware. 3 credits, 3 contact hours.

Prerequisite: IS 601 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20601) Web services enable integration of web-based applications and feature sets to any other web-based system in a modular way. Middleware is a set of functionality positioned in between and enabling interoperability among different, distributed enterprise and other computing applications. This course provides an introduction to web services and middleware in the context of digital libraries - large scale multimedia information repositories. Students will gain hands on experience in developing their own web services managing a complex distributed computing platform.

IS 698. Special topics in Information Systems. 3 credits, 3 contact hours.

Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

IS 700. Master's Project. 0 credits, 0 contact hours.

An approved project involving design, implementation, and analysis, or theoretical investigation, under the guidance of a faculty member. Students are strongly advised to work with the faculty member to develop a project proposal during the semester prior to conducting the master's project. Approval to register for the project must be obtained from the faculty member advising the project.

IS 700B. Master's Project. 3 credits, 3 contact hours.

An approved project involving design, implementation, and analysis, or theoretical investigation, under the guidance of a faculty member. Students are strongly advised to work with the faculty member to develop a project proposal during the semester prior to conducting the master's project. Approval to register for the project must be obtained from the faculty member advising the project.

IS 700C. Master's Project. 6 credits, 6 contact hours.

An approved project involving design, implementation, and analysis, or theoretical investigation, under the guidance of a faculty member. Students are strongly advised to work with the faculty member to develop a project proposal during the semester prior to conducting the master's project. Approval to register for the project must be obtained from the faculty member advising the project.

IS 701. Master's Thesis. 0 credits, 0 contact hours.
An approved research-oriented project involving design, implementation, and analysis or theoretical investigation, carried out under the supervision of a faculty member who will be the thesis advisor. The thesis should be of such depth and caliber as to warrant publication in a technical or scientific journal. Approval to register for the thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits required for the thesis. Students are strongly advised to work with the thesis advisor to develop a thesis proposal during the semester prior to commencing the project.

IS 701B. Master's Thesis. 3 credits, 3 contact hours.
An approved research-oriented project involving design, implementation, and analysis or theoretical investigation, carried out under the supervision of a faculty member who will be the thesis advisor. The thesis should be of such depth and caliber as to warrant publication in a technical or scientific journal. Approval to register for the thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits required for the thesis. Students are strongly advised to work with the thesis advisor to develop a thesis proposal during the semester prior to commencing the project.

IS 701C. Master's Thesis. 6 credits, 3 contact hours.
An approved research-oriented project involving design, implementation, and analysis or theoretical investigation, carried out under the supervision of a faculty member who will be the thesis advisor. The thesis should be of such depth and caliber as to warrant publication in a technical or scientific journal. Approval to register for the thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits required for the thesis. Students are strongly advised to work with the thesis advisor to develop a thesis proposal during the semester prior to commencing the project.

IS 725. Independent Study in Information Systems. 3 credits, 3 contact hours.
Prerequisites: Graduate standing and department consent.

IS 726. Independent Research II. 3 credits, 3 contact hours.

IS 727. Independent Research III. 3 credits, 1 contact hour.

IS 735. Social Media. 3 credits, 3 contact hours.
Prerequisite: IS 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20665) or MATH 661 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH%20661), or a graduate course in statistics or course in quantitative research methods. Seminar style course that covers design and impact of computer-based systems for human communication, including email and IM, discussion boards, Computer-Supported Cooperative Work (CSCW), Group Decision Support Systems (GDSS), and Social Networking Systems. Topics include alternative design structures, impacts of primarily text-based group communication, and recent empirical studies of virtual teams, online communities, and systems used for social networking, including 3-D worlds such as Second Life and "micro blogging" systems such as Twitter.

IS 764. Research Methods for Human-Centered Computing and Design. 3 credits, 0 contact hours.
Prerequisites: None. This introductory seminar in human centered computing and design provides a survey of the methodological literature on qualitative research methods paired with appropriate article-length exemplars. We cover a variety of different research strategies including design science, action research, case study, qualitative data collection and analysis techniques, and scenario-based design. This course develops skills in designing and evaluating systems using qualitative methods. We also discuss writing and reviewing academic articles and research proposals. The course utilizes information systems as the primary domain but could be extended for students in other disciplines.

IS 765. Quantitative Methods in Information Systems Research. 3 credits, 3 contact hours.
Prerequisite: MATH 661 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH%20661) or equivalent. This course is a practical and project-oriented introduction to quantitative methods in information systems (IS) research. The focus of the course is on developing researchers' capability to select and implement appropriate statistical procedures for a variety of research questions and to interpret the results of these procedures.

IS 766. Philosophy of Information Science. 3 credits, 3 contact hours.
This seminar explores central issues in contemporary philosophy of science. We consider "scientific" progress in the computing sciences with a focus on information systems and human computer interaction theory. We discuss topics such as confirmation and disconfirmation of theories; falsifiability and pseudo-science; introduction; probability; and statistical inference, prediction, explanation and empirical equivalence. We read key works by philosophers such as Popper and Kuhn. We examine the notion of "design science" and contrast it with "natural science", and examine whether social science research should strive to emulate natural science methods. Readings will be tied into research within information systems and the computing sciences in general, looking at how scientific theories are tested or confirmed.

IS 776. IS Research Proposition. 3 credits, 3 contact hours.
Prerequisite: Restricted to students in the doctoral program in Information Systems. The IS Research Study serves as the Information Systems PhD qualifying exam and demonstrates research readiness. Each student works with a faculty member to identify the topic of a research study, and then takes the lead in designing and conducting the study, and analyzing the results.

IS 785. ST: 3 credits, 3 contact hours.
These seminars examine a special interest area of Information Systems in depth. Each seminar emphasizes recent work in the area selected.

IS 786. Special Topics. 3 credits, 3 contact hours.
These seminars examine a special interest area of Information Systems in depth. Each seminar emphasizes recent work in the area selected.

IS 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790C. Doct Dissertation & Res. 6 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 790F. Doct Dissertation & Res. 15 credits, 3 contact hours.
For PhD students who have completed the qualifying exam. Research and writing are carried out under the supervision of a designed graduate faculty member. The completed dissertation should be a substantial contribution to the knowledge of the topic under research, and of sufficient merit to warrant publication in a leading scientific or technical journal.

IS 791. Graduate Seminar. 0 credits, 0 contact hours.
A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in information systems. In the course students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

IS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Prerequisite: permission from department chairperson. For students admitted to the doctoral program in IS who have passed the field exam or the qualifying examination. Research is carried out under the supervision of a designated faculty member. Students identify a research problem and prepare a plan to solve the problem. A maximum of 6 credits of IS 792 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20792) may be applied to the IS 790 (http://catalog.njit.edu/archive/2019-2020/search/?P=IS%20790) requirement.

IT 610. System Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course is an introduction to the skills needed for and tasks performed by a System Administrator. The course will cover administration of host and server systems in modern operating system environments. Topics to be covered include: user, configuration, and change management, shell scripting, monitoring and performance analysis, disaster mitigation and recovery, and auditing.

IT 620. Wireless Networks Security and Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course introduces the fundamentals of wireless network security and administration. Topics include: wireless LAN vulnerabilities, passive and active wireless attacks, enterprise wireless hardware security, secure wireless authentication and communication, wireless intrusion detection and prevention systems, WiFi and cellular network management, location privacy, personal area network administration and security, mobile IP security, GSM, CDPD, 3G and 4G network security. The course provides both a theoretical foundation and hands-on experience in these areas.

IT 635. Database Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course provides a broad overview of the tasks and techniques necessary to function as a Database Administrator (DBA)in a modern relational database environment. Students will learn the duties typically performed by a DBA, which include: user authorization, disaster planning and recovery, monitoring, performance analysis, database tuning, metadata maintenance as well as data modeling, analysis and database design.

IT 640. Network Services Administration. 3 credits, 3 contact hours.
Prerequisite: Completion of the Bridge requirements for the MS in IT Administration and Security (or the equivalent). This course provides an introduction to the fundamentals of network services administration. It covers how web-based and domain-services operate, integrate and communicate. Topics include: fundamental technologies that underpin the web services paradigm, key standards necessary for their development, and how other critical domain services should be deployed. This course will enable students to gain skills necessary to plan, install, configure, secure and maintain web servers, DNS servers, email & print servers, resource sharing systems, and domain authentication systems.

IT 725. Independent Study. 3 credits, 3 contact hours.

College of Science and Liberal Arts

The College of Science and Liberal Arts (CSLA) is the home of discovery and scholarship with strong programs in the traditional disciplines of biology, chemistry, physics, mathematics and history. CSLA also is the home of interdisciplinary programs that include communication and media; law, technology and culture; science, technology and society; environmental science; and theatre arts and technology. The sciences and liberal arts have long been the foundation of a university education and they allow us to address the complexities of modern life at the intersection of science, technology, and human values.

With over 150 full-time teachers and researchers, the CSLA community represents a wide range of interests, but also shares the value of academic excellence. CSLA faculty and students are at the forefront of many national research activities, including solar astronomy, mathematical modeling, and the history of medicine and technology.

CSLA provides students with the intellectual foundations necessary to understand and analyze the technological world in which we live. The college's courses and degrees prepare students to ask questions about the world, to collect data and provide evidence, and to express ideas and conclusions with clarity and precision. These skills transcend specific professional competence and distinguish CSLA students as individuals who can blaze a trail for others and lead society into a rapidly evolving future.

Programs

- Applied Mathematics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-mathematics-ms/)
- Applied Physics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/applied-physics-ms/)
- Applied Statistics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistics-ms/)
- Applied Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/applied-sciences-ms/)
- Biology - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/biology/ms/)
- BioStatistics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/biostatistics-ms/)
- Chemistry - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/chemistry-ms/)
- Environmental Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/)
- History - M.A. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/history/ms/)
- Materials Science and Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/materials-science-engineering-ms/)

- Mathematical and Computational Finance - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/mathematical-computational-finance-ms/)
- Pharmaceutical Chemistry - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/pharmaceutical-chemistry-ms/)
- Professional and Technical Communication - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Programs

- Applied Physics - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/applied-physics-phd/)
- Biology - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/biology/phd/)
- Chemistry - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/chemistry-phd/)
- Environmental Science - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-phd/)
- Materials Science & Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/materials-science-engineering-phd/)
- Mathematical Sciences - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/phd/)

Programs

- Applied Science (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/applied-science-cert/)
- Applied Statistical Methods (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistical-methods-cert/)
- Biostatistics Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/biostatistics-essentials-cert/)
- Biotechnology (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/biology/biotechnology-cert/)
- Clinical Trials: Design and Analysis (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/clinical-trials_design-and-analysis-cert/)
- Digital Marketing Design Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/digital-marketing-design-essentials-cert/)
- Environmental Science (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-cert/)
- Environmental Science and Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-engineering-cert/)
- Instructional Design, Evaluation and Assessment (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/instructional-design-evaluation-assessment-cert/)
- Neuroscience (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/biology/neuroscience-cert/)
- Social Media Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/social-media-essentials-cert/)
- Technical Communication Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/technical-communication-essentials-cert/)
- User Experience Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/user-experience-essentials-cert/)

College of Science and Liberal Arts Courses

BIOL 590. Grad Coop Work Experience I. 1 credit, 1 contact hour.

BIOL 591. Graduate Coop Work Exper II. 1 credit, 1 contact hour.

BIOL 593. Graduate Co-Op Work Exp IV. 0 credits, 0 contact hours.

BIOL 601. Computational Biology I. 3 credits, 3 contact hours.
This course will describe mathematical and simulation techniques used in modeling a variety of biological systems. Students will learn stability analysis, phase space analysis, basic bifurication theory and numerical simulation techniques with examples from neuroscience, cell and molecular biology as well as ecology and evolution. Students enrolling in this course are expected to have basic knowledge of calculus, linear algebra and some programming abilities.

BIOL 605. Prin of Bioscience Processing. 3 credits, 3 contact hours.
This course covers the main concepts of cell physiology, molecular biology, and cell biology. The fundamental aspects of biochemistry that relate directly to pharmaceutical developments are discussed and include basic organic chemistry, blood and buffers, protein based enzymes, complex carbohydrates, nucleic acids, and fats. Those topics will then be integrated into a thorough understanding of Bioprocessing in pharmaceutical industries. This course is for Professional Science Master's Biotechnology students with limited knowledge of Biology.

BIOL 606. App Bioproc & Immun Based Ther. 3 credits, 3 contact hours.
Prerequisite: BIOL 605 or permission of the instructor. This course provides foundational knowledge about immunology and immunological applications relevant to bioprocessing science including immunoglobulin genetics, leukocyte activation and migration, transplant immunology, and immunotherapy and vaccines.

BIOL 610. Comparative Vertebrate Anatomy. 3 credits, 3 contact hours.
This course introduces students to the groups of vertebrates and explores the anatomical evolution of vertebrates within the context of the functional interrelationships of organs and the changing environments to which vertebrates have adapted. An ideal entry point into the ways living creatures interact with their immediate physical world, we examine how the forms and activities of animals reflect the materials available to nature and consider rules for structural design under environmental forces.

BIOL 612. Comparative Animal Physiology. 3 credits, 3 contact hours.
This course will explore how animals, from invertebrates to vertebrates, function from the cellular to the organism level. The study of the structure and function of the various organs provides insight into how animals survive extreme environments and how they respond to changes in their environment. The comparative approach shows that the underlying physiological principles that govern life are common to all animals and yet animals have evolved unique and sometimes startling physiological solutions to problems posed by their particular environments.

BIOL 622. Evolution. 3 credits, 3 contact hours.
This course will provide a comprehensive overview of research in the field of evolutionary biology. Topics will include: the development of evolutionary theory, the history of the evolution of life on Earth, the genetic bases of variation and heredity, natural selection, evolution and development, and speciation. The format will be brief lectures to review topics covered in text, followed by class discussions of relevant primary literature. Students will write two papers on the topic of their choice and will be required to lead a minimum of one class discussion.

BIOL 628. Cell Biology of Disease: Cells Gone Bad. 3 credits, 3 contact hours.
This course will briefly review normal physiological function of humans and will then extensively explore the basis of many human diseases at cellular lever. The goal is to understand how alterations in normal cell functions affect human physiology by reviewing current research in the field of cell biology.

BIOL 630. Critical Thinking for the Life Sciences. 3 credits, 3 contact hours.
Researchers in the biological sciences must understand and be able to effectively apply the scientific method, and they must also be able to clearly communicate their ideas and results. This course will involve heavy student participation and discuss the scientific method, analyze and discuss data gathering and organizing, and will analyze existing grant proposals with the goal of enabling graduate students to write a clear and convincing grant proposal.

BIOL 631. Proposal Prep for Extnl Fundin. 3 credits, 3 contact hours.
Prerequisite: BIOL 630. This course is intended for doctoral students in their first or second year who intend to apply for external funding for their research. The course is hands-on and students are required to identify sources of funding and to write and submit a grant proposal. Topics covered include developing research questions and hypotheses, organization of specific aims, components of the proposal, including significance, innovation, expected outcomes, potential pitfalls and broader impact. The course also emphasizes practices of good grantsmanship and provides an overview of how proposals are reviewed at NSF and NIH.

BIOL 635. Intro to Comp Neuroscience. 3 credits, 3 contact hours.
Prerequisite: Permission by instructor. Introduction to the modeling, computational and analysis techniques for single neurons and small neuronal networks. The course work is designed so that students can develop an independent modeling/computational project by the end of the semester. The required knowledge of neurobiology, electric circuits and numerical tools for the solution of differential equations will be introduced as needed.

BIOL 636. Advanced Comp Neuroscience. 3 credits, 3 contact hours.
Prerequisites: BIOL 635 or permission by the instructor. Modeling and computational analysis of biological neuronal networks. The course consists of lectures, scientific paper presentations and computational work. Students are expected to develop an independent modeling/computational project by the end of the semester.

BIOL 638. Computational Ecology. 3 credits, 3 contact hours.
An overview of computational approaches to the study of mathematical models in ecology. Topics include one-, two-, and multi-species models, life history analysis, spatial dynamics, epidemiology. The course is taught as a hands-on computer lab in which students explore models, perform simulations and solve problems.

BIOL 640. Cellular Neurophysiology. 3 credits, 3 contact hours.
Prerequisites: Graduate student status or permission of the instructor. This course will examine the nervous system from a functional perspective. The goal is to understand how ion channels and other components of nerve cells give rise to electrical excitability and synaptic function, and how those properties are then used for coding information and higher order function in the nervous system.

BIOL 641. Systems Neuroscience. 3 credits, 3 contact hours.
This course will examine neurophysical phenomena from a systems perspective. The course will review basic concepts of cellular neuroscience, such as excitability, impulse conduction, and integration of activity at the cellular, before focusing on network level physiology of the nervous system and its role in the generation of behavior. The goal is to provide students with the basic knowledge to understand neurobiological processes at all levels of complexity.

BIOL 645. Biological Imaging Techniques. 3 credits, 3 contact hours.
Prerequisites: Graduate student status or permission of the instructor. This combined lecture and lab course will introduce the students to a variety of approaches to examine biological structures at different microscopic scales: conventional light microscopy, fluorescent microscopy, modern high resolution light microscopy, and electron microscopy. In addition, the course will cover optical approaches to study the dynamics of cellular function, including calcium and voltage imaging, and molecular interactions.

BIOL 660. College Teaching. 3 credits, 3 contact hours.
College Teaching helps students in STEM fields who teach or plan to teach in colleges or universities develop important professional knowledge, skills, values, and dispositions that can enable them to help undergraduate and graduate students develop societally and personally significant abilities. The course emphasizes research-based methods demonstrated to be effective for enhancing learning in diverse people.

BIOL 672. Computational Systems Biology. 3 credits, 3 contact hours.
Prerequisite: Permission by the instructor. Introduction to the mathematical and computational modeling of biological systems with a focus on chemical, biochemical, metabolic and genetic networks. The course work is designed so that students can develop an independent modeling/computational project by the end of the semester. The required knowledge of biology and numerical tools for the solution of differential equations will be introduced as needed.

BIOL 698. Selected topics in Biology. 3 credits, 3 contact hours.
Survey of recent research topics in Biology at the Master's level.

BIOL 699. Selected Topics in Biology. 3 credits, 3 contact hours.
Survey of recent research topics in Biology at the Masters level.

BIOL 700. Master's Project. 0 credits, 0 contact hours.

BIOL 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology. A written report must be submitted to the project advisor. The student cannot register in BIOL 700B more than once and the incomplete (I) grade is not allowed.

BIOL 701. Master's Thesis. 0 credits, 0 contact hours.

BIOL 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in BIOL 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

BIOL 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (BIOL 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

BIOL 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

BIOL 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for BIOL 726 if they have taken BIOL 725 in a prior semester.

BIOL 788. Selected Topics in Biology. 3 credits, 3 contact hours.
Survey of recent research topics in Biology at the doctoral level.

BIOL 790. Doct Dissertation & Resrch. 0 credits, 0 contact hours.

BIOL 790A. Doct Dissertation & Resrch. 1 credit, 1 contact hour.
Co-requisite: BIOL 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology. For PhD students who have successfully defended their dissertation proposal. The student must register in BIOL 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

BIOL 790B. Doct Dissertation & Resrch. 3 credits, 3 contact hours.
Co-requisite: BIOL 791. Since the BIOL 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in biology. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

BIOL 790C. Doctoral Dissertn & Resrch. 6 credits, 6 contact hours.
Co-requisite: BIOL 791. Since the BIOL 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in biology. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

BIOL 790D. Doct Dissertation & Resrch. 9 credits, 0 contact hours.

BIOL 790E. Doctoral Dissertation. 12 credits, 12 contact hours.

BIOL 791. Biology Seminar. 0 credits, 0 contact hours.
This seminar includes student and faculty presentations on current papers, student presentations related to their research and occasional outside speakers. It will acquaint students with possible topics for dissertation search, and provide an opportunity to present and receive feedback on current work.

BIOL 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: BIOL 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in biology. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

BIOL 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

BIOL 792D. Pre-Doctoral Research. 12 credits, 12 contact hours.

BIOL 794. Computational Biology Colloquium. 1 credit, 1 contact hour.
Restriction: graduate standing. Students and outside speakers present and discuss current research activities in computational biology and related scientific areas.

CHEM 590. Graduate Co-Op Work Exper I. 1 credit, 1 contact hour.

CHEM 591. Graduate Co-Op Work Exper II. 1 credit, 1 contact hour.

CHEM 592. Graduate Co-Op Work Exper III. 1 credit, 1 contact hour.

CHEM 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CHEM 599. Methods for Teaching Assistants and Graduate Assistants. 3 credits, 3 contact hours.
Restriction: graduate standing. Required for all chemistry teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

CHEM 601. Special Topics in Chemistry I. 3 credits, 3 contact hours.
Restriction: graduate standing and permission of the instructor. Topics of current interest in chemistry.

CHEM 605. Advanced Organic Chemistry I: Structure. 3 credits, 3 contact hours.
Prerequisite: undergraduate organic chemistry. Structure of organic molecules. Topics include atomic and molecular structure, stereochemistry, reactive intermediates (cations, anions, radicals, and carbenes), orbital symmetry, and spectroscopy.

CHEM 606. Physical Organic Chemistry. 3 credits, 3 contact hours.
Prerequisite: CHEM 502 or equivalent. Emphasis is placed on the physical aspects of the subject. Determination of reaction mechanisms, equilibria, and kinetics using simple molecular orbital theory and absolute reaction rate theory.

CHEM 610. Advanced Inorganic Chemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate physical chemistry or permission of the instructor. Theories of observed chemical and physical properties of the elements and their compounds; prediction of reactivity and properties of proposed new compounds.

CHEM 617. Mass Spectrometry and Interpretation of Mass Spectra. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM 126 or equivalent. Historical background, fundamentals and mechanics of operation for components incorporated into modern Mass Spectrometers: vacuum system, ion sources, mass filter, ion detection, plus computer operation and data collection. Explanation and interpretation of mass spectra and fragmentation patterns are a fundamental theme throughout the course. Lecture material includes principles of operation and appropriate applications for modern types of mass spectrometers: magnetic sector, quadrupole, time of flight, ion trap, FT-ICR. Theory and applications of electron impact, chemical, electrospray, and other ionization techniques including atmospheric sampling are covered. High resolution analysis using magnetic sector and FT - ion cyclotron instruments. Analytical applications in environmental, petroleum and biochemical analysis and applications and coupling of mass spectrometry with other instruments (GC, LC, AES,) are illustrated.

CHEM 658. Advanced Physical Chemistry. 3 credits, 3 contact hours.
Prerequisite: one year of undergraduate physical chemistry. Principles and applications of quantum chemistry; the wave equation, its properties and mathematics; the Schrodinger equation and wave functions; the harmonic oscillator; variational and perturbational methods; atomic theory, structure, and properties; simple molecules, LCAO and valence bond theories; semi-empirical methods; time dependence, and introduction to electronic and vibration-rotation spectroscopy.

CHEM 661. Instrumental Analysis Laboratory. 3 credits, 3 contact hours.
Prerequisite: one year of undergraduate physical chemistry. Instruments for chemical analysis are discussed in class and used in the laboratory; basic theory; sample preparation; use of instruments and interpretation of data are covered for spectroscopy including UV0VIS, FTIR, AA, and NMR; HPLC, GC, ion chromatography, mass spectrometry. Applications to food science, pharmaceuticals, polymers, and other chemical areas.

CHEM 662. Air Pollution Analysis. 3 credits, 4 contact hours.
Prerequisite: undergraduate physical chemistry. Chemical and physical principles of gaseous species and trace level measurement techniques for airborne vapors and particulates. Emphasis on analyzing real air samples at the parts-per-billion level, meteorological dispersion and life times of pollutants are covered. Laboratory work in air pollution sampling methods for vapor and particulate species. Determination of primary air pollutants using wet chemical and instrumental techniques.

CHEM 664. Advanced Analytical Chemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate physical chemistry. The principles of chemical analysis as they apply to chromatography, electrochemistry, and spectroscopy. Sampling considerations, separations, and sample preparation steps. This course is a useful adjunct to CHEM 661, where these analytical techniques are considered in a more practical way.

CHEM 673. Biochemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate organic and physical chemistry, or suitable background in these subjects. Fundamentals of biochemistry related to physical organic chemistry for students who have an interest in biomedical engineering, chemistry, chemical engineering, or environmental science.

CHEM 700. Masters Project. 0 credits, 0 contact hours.
Prerequisite: matriculation for the master's degree. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Approval to register for the master's project must be obtained from the project advisor. Students must continue to register for at least 3 credits each semester until the project is completed and a written report is accepted. Only a total of 3 credits will count toward the degree.

CHEM 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry. A written report must be submitted to the project advisor. The student cannot register in CHEM 700B more than once and the incomplete (I) grade is not allowed.

CHEM 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the master's degree in applied chemistry. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the department, and one other faculty member. Once registration for thesis has begun, a student must continue to register for a minimum of 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

CHEM 701B. Masters Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CHEM 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHEM 701C. Masters Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CHEM 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHEM 702. Special Topics in Chemistry II. 3 credits, 3 contact hours.
Restriction: Graduate standing. Topics of current interest in chemistry.

CHEM 714. Pharmaceutical Analysis. 3 credits, 3 contact hours.
The objective of this course is to provide an overview of instrumental techniques used in the analysis of different pharmaceutical products. Many different types of analysis are carried out in the pharmaceutical industry pertaining to active ingredients, formulations as well as impurities and dgradants. The focus will be on instrumentation such as chromatography, mass spectroscopy, different types of spectroscopy, quality assurance and GMP.

CHEM 716. Integrated Drug Dev & Discover. 3 credits, 3 contact hours.
Prerequisites: Strong background in organic chemistry This course offers an overview of the drug development process combined with hands-on experience in computer-aided drug design. Topics include pharmacokinetics, bioavailability, drug formulation, and structure-based drug design.

CHEM 717. Mass Spectrometry and Mass Spectral Interpretation. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM126 or equivalent. CHEM 717 and EVSC 617 are comprised of CHWM 717 and EVSC 617 plus a research project: Research projects usually comprise experimental and mass spectrometry interpretation studies. These can be performed at NJIT or in the students corporate mass spectrometry facility. Projects may also include theory, data interpretation or literature reviews pertinent to a current active area in mass spectrometry research. Projects should be approved or in consult with the instructors.

CHEM 718. Organic Synthesis. 3 credits, 3 contact hours.
Organic Synthesis is widely used in the production of organic materials and pharmaceutical drugs. The course introduces modern synthetic methods to the graduate students of NJIT. The first part of the course teaches organic reactions categorized by their roles in synthesis. Topics include substitution and addition of carbon nucleophiles, functional group conversion, oxidation, reduction, concerted cycloadditions, aromatic substitutions, and organometallic catalysis. The second part of the course teaches general strategies to develop synthetic plans, special considerations for difficult synthetic targets, and examples of natural product synthesis.

CHEM 719. Drug Delivery Systems. 3 credits, 3 contact hours.
Prerequisites: Strong background in organic chemistry This course emphasizes the importance of effective drug delivery to achieve specific therapeutic outcomes. Students learn current trends in research on the design of drug delivery systems to release drug content in a controllable and targeted manner.

CHEM 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CHEM 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for CHEM 726 if they have taken CHEM 725 in a prior semester.

CHEM 727. Independent Study III. 3 credits, 3 contact hours.
Restriction: written permission from the Associate Chairperson for Environmental Science plus courses prescribed by the supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which are not sufficiently broad to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHEM 734. Thermochemical Kinetics-Detailed Mechanistic Modeling. 3 credits, 3 contact hours.
Prerequisite: graduate level course in either kinetics or reactor design, or permission of instructor. Quantitative estimation of thermochemical data and chemical reactions in the vapor phase, and to some extent in the liquid phase; theories of transition state, RRKM, and Quantum RRK; and detailed chemical modeling concepts for reactor design. Applied computer project is required.

CHEM 735. Combustion. 3 credits, 3 contact hours.
Prerequisite: thermodynamics and kinetics or equivalent, or permission of instructor. Thermodynamic properties of stable molecules and free radical species in combustion and oxidation of aliphatic hydrocarbons; reactions occurring in high temperature combustion systems; and related kinetic principles.

CHEM 737. Applications of Computational Chemistry and Molecular Modeling. 3 credits, 3 contact hours.
Students are exposed to hands-on applications and fundamental aspects of computational chemistry and molecular modeling in organic, inorganic, bio- and physical chemistry. The course provides methods to determine the thermochemistry of a reaction, and strength (energy)of interactions by organic drug-like molecules with proteins. The course teaches the student to evaluate relative energy of different structures plus chemical species stability, reactivity and equilibrium ratios in chemical environments.

CHEM 748. Nanomaterials. 3 credits, 3 contact hours.
New feature of the 700 level course will be hands-on small projects carried out by groups of two students in Professor Iqbal's laboratories during the second half of the semester. The projects will be selected from the topics covered in the course. A second feature will involve a lecture on a specialized nanomaterial topic given by an invited outside lecturer. This 3 credit interdisciplinary course is designed to teach and provide hands-on project experience to M.S. and Ph.D. graduate students in chemistry, physics/materials science, and chemical/biomedical/electrical engineering on the fundamentals, synthesis, characterization and applications of nanomaterials. 75% of the course will comprise of lectures-one or two of which will be given by invited outside lecturers. 25% of the course will involve small projects based on the syllabus and conducted in the research laboratories of the instructor.

CHEM 764. Advanced Analytical Chemistry. 3 credits, 3 contact hours.
Prerequisites: undergraduate General and Analytical Chemistry. The principles of chemical analysis as they apply to chromatography, electrochemistry, and spectroscopy. Sampling considerations, separations, and sample preparation steps. This course is a useful adjunct to CHEM 661, where these analytical techniques are considered in a more practical way.

CHEM 777. Principles Pharm Chemistry. 3 credits, 3 contact hours.
Teaches about drug design, and the molecular mechanisms by which drugs act in the body. Covers pharmacodynamics, pharmacokinetics, molecular targets used by drugs, the interaction of a drug with a target, and the consequences of this interaction. Covers strategies used in discovering and designing new drugs, and surveys the "tools of the trade" involved, e.g., QSAR, combichem and computer aided design. Covers special topics like chlorinergics, analgesics, opiates, antibacterials, antivirals, and antiulcer agents.

CHEM 790. Doctoral Dissertation. 0 credits, 0 contact hours.

CHEM 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Co-requisite: CHEM 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry. For PhD students who have successfully defended their dissertation proposal. The student must register in CHEM 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

CHEM 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Co-requisite: CHEM 791. Since the CHEM 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

CHEM 790C. Doctoral Dissertation. 6 credits, 6 contact hours.
Co-requisite: CHEM 791. Since the CHEM 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in chemistry. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

CHEM 790D. Doctoral Dissertation. 9 credits, 3 contact hours.

CHEM 790E. Doctoral Dissertation. 12 credits, 3 contact hours.

CHEM 790F. Doctoral Dissertation. 15 credits, 15 contact hours.

CHEM 790G. Doctoral Dissertation. 18 credits, 18 contact hours.

CHEM 791. Graduate Seminar. 0 credits, 0 contact hours.
Required of all chemistry graduate students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

CHEM 792. Pre-Doctoral Research. 3 credits, 3 contact hours.

CHEM 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: CHEM 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in chemistry. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

CHEM 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

ENG 502. English for International Graduate Students. 3 credits, 3 contact hours.
Practice in writing to improve sentence structure, grammar, vocabulary, and organization. For technical writing, see ENG 541. Level: High Intermediate.

ENG 503. Advanced English for International Teaching Assistants. 3 credits, 3 contact hours.
Practice in public speaking for international TAS and other international students who want to improve their oral presentation skills. Also covers teaching techniques and pronunciation. Level: Advanced.

ENG 505. Advanced Spoken English for International Graduate Students. 3 credits, 3 contact hours.
Designed to improve English pronunciation; accent reduction. Level: Advanced.

ENG 507. Advanced Conversation and American Culture. 3 credits, 3 contact hours.
Practice in conversation in English at an advanced level. The goal is to help students gain the cultural knowledge and speaking skills to increase participation in American life. Level: Advanced.

ENG 521. Technical Written and Oral Communication. 3 credits, 3 contact hours.
Develops skill in oral and written technical communication on a professional level. Three areas are emphasized: 1) analyzing professional and technical communication situations; 2) achieving clear, effective oral and written communication; and 3) developing awareness of variations in professional communication across cultures. For some assignments, students will work on projects from courses in their own fields. The approach is practical; course format is that of a workshop. Non-native speakers of English may take this course.

EPS 601. Research Methods for Environment and Sustainability Policy. 3 credits, 3 contact hours.
Introduces the research methods necessary to conduct studies in environmental and sustainability policy. Topics covered include literature review, problem identification, hypothesis testing, and quantitative methods of data analysis and problem solving. Students are required to implement and present their independently designed projects.

EPS 602. Research Analysis for the Social and Policy Sciences. 3 credits, 3 contact hours.
Prerequisite: EPS 601. Distribution of social, political, economic and health-related data in both samples and populations using a general linear model with residuals. Test hypotheses using both the Fisher and Neyman-Pearson criteria. Use of software such as SPSS, Microsoft Excel and Resampling Stats. to develop and test models using correlation, regression and ANOV techniques.

EPS 609. Environmental Risk Assessment. 3 credits, 3 contact hours.
Methodology to assess the social and economic risks to present-day environmental resources of air and water; cost-benefit and trade-off analysis; technical characteristics of materials such as half-life, decomposition rates, and temperature sensitivity; and probabilities of various environmental situations.

EPS 612. Introduction to Environmental Policy Studies. 3 credits, 3 contact hours.
Introduction to six areas essential to a comprehensive understanding of environmental policy: concept of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio); industrial perspective (pollution prevention/life cycle engineering, privatization); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline.) Same as MIP 612.

EPS 613. Environmental History and Policy. 3 credits, 3 contact hours.
Explores the dialogue between humanity and the environment in the United States, as well as its global implications. Surveys fundamental themes of history and policy from an environmental perspective: colonial development, independence, western expansion, industrialization, urbanization, and the rise of a consumer society. Gives special attention to the emergence of an environmental perspective: wilderness appreciation, the conservation movement, public health, the rise of the environmental movement since the 1960s, environmental science, and the legislative and regulatory process.

EPS 614. Environmental Economics and Management. 3 credits, 3 contact hours.
Overviews the complex and dynamic interactions between the economy and the environment from biological, economic, and institutional perspectives and investigates various strategies for resolving conflicts in resource management and pollution control. Topics include the basic principles of risk assessment, cost benefit analysis, and cost-effectiveness analysis in environment management and assessment of contemporary environment politics in air and water pollution control and waste and toxics management.

EPS 622. Sustainable Politics and Policy. 3 credits, 3 contact hours.
Identifies the origins of the concept of sustainability development and institutional efforts to implement strategies at various geopolitical scales: international, national, regional, and local. The course introduces tools to measure progress toward sustainability through the use of metrics such as ecological footprint analysis and life-cycle analysis. Other topics include steady-state economics, sustainable systems of production and consumption, and sustainability transitions.

EPS 638. Physical Geography. 3 credits, 3 contact hours.
Understanding the interaction between humans and the physical environment is important to the formulation of sound environmental policy. The course examines processes that shape the physical environment, the influence of human activities on these processes and the physical environment, and the application of this information to solving environmental problems.

EPS 644. The Rhetoric of Environmental Policy. 3 credits, 3 contact hours.
Introduces students to the major types of rhetorical analysis as well as assures that students can analyze and write technology policy that is informed by core rhetorical principles of that analysis.

EPS 651. Introduction to Urban and Environmental Health. 3 credits, 3 contact hours.
Health problems associated with the social and psychological factors found in urban areas and health problems stemming from contamination of air, water, food, the work place and other special environments. Policies required to promote healthful living behavior and those required to regulate negative externalities.

EPS 660. Ethics and Environmental Policy. 3 credits, 3 contact hours.
Contemporary environmental problems from the perspective of ethics or moral philosophy. Is there a moral obligation to preserve or protect the natural environment? What are the ethical presumptions and values underlying environmental policy? Are traditional theories of moral philosophy applicable to contemporary environmental problems, or is a new conception of the relationship between humanity and nature needed?.

EPS 698. ST:. 3 credits, 3 contact hours.
Course considers advanced topics of special or current interest related to environmental and sustainability policy.

EPS 699. ST:. 3 credits, 3 contact hours.
Course considers advanced topics of special or current interest related to environmental and sustainability policy.

EPS 700. Master'S Project. 0 credits, 0 contact hours.

EPS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental and sustainability policy. A written report must be submitted to the project advisor. The student cannot register in EPS 700B more than once and the incomplete (I) grade is not allowed.

EPS 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the master's degree, advisor's and departmental approval. Projects involving fieldwork, experimental, or theoretical investigation carried out under the supervision of a designated member of the departmental faculty. The completed thesis should be of a quality as to warrant publication, in whole or in part, in a professional journal. A minimum of 3 credits per semester is required until completion.

EPS 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental and sustainability policy that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in EPS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EPS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental and sustainability policy that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (EPS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EPS 702. Special Topics. 3 credits, 3 contact hours.
Restriction: Approval of graduate advisor in Environmental Science. Topics of current interest in the field of environmental policy. Doctoral level course.

EPS 712. Advanced Studies in Environmental and Sustainability Policy. 3 credits, 3 contact hours.
Evaluates strategies to reduce energy and material throughput including eco-efficiency relocalization of production and consumption, and green consumerism. Also considered are debates surrounding innovative policies to foster work-time reduction, to develop alternative measures of well-being, and to include societal values shifts.

EPS 714. Environmental and Natural Resources Economics. 3 credits, 3 contact hours.
Examines environmental regulation of firms and natural resource use with emphasis on the theoretical foundations required for public policy. Students focus primarily on the application of economic tools to improve environmental quality.

EPS 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

EPS 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for EPS 726 if they have taken EPS 725 in a prior semester.

EVSC 591. Graduate Work Experience I. 1 credit, 1 contact hour.
Restriction: permission of the associate chairperson for environmental science and the Division of Career Development Services. Provides on-the-job reinforcement of environmental science assignments. Projects are developed by the co-op office in consultation with the associate chairperson for environmental science. Cannot be used for degree credit.

EVSC 592. Graduate Work Experience II. 1 credit, 1 contact hour.
Restriction: permission of the associate chairperson for environmental science and the Division of Career Development Services. Provides on-the-job reinforcement of environmental science assignments. Projects are developed by the co-op office in consultation with the associate chairperson for environmental science. Cannot be used for degree credit.

EVSC 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

EVSC 600. Environmental Science Seminar. 0 credits, 3 contact hours.
Restriction: graduate standing. Current environmental topics of interest to the environmental professional are presented. Required every semester for environmental science graduate students receiving departmental or research-based awards and for all doctoral students.

EVSC 602. Special Topics in Environmental Science I. 3 credits, 3 contact hours.
Restriction: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EVSC 603. Hazardous Waste Operations and Emergency Response. 3 credits, 3 contact hours.
Explores the safe operation of hazardous waste sites as well as emergency responses to hazardous releases. Overview of OSHA regulations and NIOSH standards concerning toxicological hazards and medical surveillance requirements. Emphasis on recognition and monitoring of site hazards. A written health and safety plan, and participation in a group problem involving a simulated hazardous site entry using actual protective equipment is required. Course satisfies the regulatory compliance mandates to meet 29 CFR 1910.120 for OSHA, with certification valid for one year.

EVSC 610. Environmental Chemical Science. 3 credits, 3 contact hours.
Restriction: graduate standing. Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.

EVSC 611. Hazardous Waste Management. 3 credits, 3 contact hours.
Restriction: graduate standing. An overview of hazardous waste management; case histories; legislation and regulations; treatment, disposal and cleanup technologies; sampling and analysis methodology; persistence and fate in the environment; emergency response procedures.

EVSC 612. Environmental Analysis. 3 credits, 4 contact hours.
Restriction: graduate standing. The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.

EVSC 613. Environmental Problem Solving. 3 credits, 3 contact hours.
Restriction: graduate standing. This course is designed to study solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.

EVSC 614. Quantitative Environmental Risk Assessment. 3 credits, 3 contact hours.
Restriction: graduate standing. Applications ofquantitative risk assessment concepts to the management of environmental problems.

EVSC 615. Global Environmental Problems. 3 credits, 3 contact hours.
Restriction: graduate standing. With an understanding that environmental problems are not restricted by geographical boundaries, relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies are studied.

EVSC 616. Toxicology. 3 credits, 3 contact hours.
Restriction: graduate standing. The general principles of toxicology are presented and applied to the assessment of acute, subacute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.

EVSC 617. Mass Spectrometry and Interpretation of Mass Spectra. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM 126 or equivalent. Historical background, fundamentals and mechanics of operation for components incorporated into modern Mass Spectrometers: vacuum system, ion sources, mass filter, ion detection, plus computer operation and data collection. Explanation and interpretation of mass spectra and fragmentation patterns are a fundamental theme throughout the course. Lecture material includes principles of operation and appropriate applications for modern types of mass spectrometers: magnetic sector, quadrupole, time of flight, ion trap, FT-ICR. Theory and applications of electron impact, chemical, electrospray, and other ionization techniques including atmospheric sampling are covered. High resolution analysis using magnetic sector and FT - ion cyclotron instruments. Analytical applications in environmental, petroleum and biochemical analysis and applications and coupling of mass spectrometry with other instruments (GC, LC, AES,) are illustrated.

EVSC 621. Ecological Risk Assessment. 3 credits, 3 contact hours.

EVSC 622. Bioremediation. 3 credits, 3 contact hours.

EVSC 623. Environmental Health. 3 credits, 3 contact hours.

EVSC 624. Environmental Analysis Methods and Laboratory. 3 credits, 4 contact hours.
Basic theory, methods, instruments, and data interpretation for chemical analysis of environmental samples are described in lectures and used in the laboratory; sampling; sample preparation; quality assurance, chain of custody. Instrument methods and uses include: UV-VIS, FTIR, AA, HPLC, GC, Ion Chromatography, and Mass Spectrometry as applied to environmental samples.

EVSC 625. Social Dimensions of Risk. 3 credits, 3 contact hours.
Low-probability/high consequence events involving terrorism, food safety, and extreme weather offer ample evidence the prevalent approaches of economics and statistics are not able to deal with the complex ways that risk permeates modern societies. This course treats risk analysis as a broad interdisciplinary activity and draws on the full range of the social sciences to explore the multifaceted way that risk infuses itself into the fabric of contemporary affairs.

EVSC 626. Hydrogeology. 3 credits, 3 contact hours.
This course covers the principles of ground water flow, advanced water cycle properties, aquifer flow and aquifer recharge. Contaminant migration and remediation methods are discussed. Basic groundwater chemistry and quality is covered.

EVSC 627. Environmental Microbiology. 3 credits, 3 contact hours.
Prerequisites: R120 101, R120 102, (General Biology I and II) or permission of instructor. This course offers an overview of 1) basic microbiology: biochemical principles, cell structure organization, microbial nutrition and growth, 2) the important microbes involved in environmental microbiology and address the environments where they are found, and 3) how they are detected and monitored, and their effects on humans, and the environment. Traditional lectures and exams are supplemented with discussions of current research articles.

EVSC 700. Masters Project. 0 credits, 0 contact hours.
Prerequisite: graduate standing and approval of the graduate advisor in environmental science. Written report requiring experimental or theoretical research, or an extensive literature analysis. Registration must be approved by an advisor. Students must continue to register for 3 credits each semester until completion and a written report is accepted. Only a total of 3 credits will count toward the degree.

EVSC 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science. A written report must be submitted to the project advisor. The student cannot register in EVSC 700B more than once and the incomplete (I) grade is not allowed.

EVSC 701. Masters Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for a master's degree in environmental science. Approval to register for the thesis must be obtained from the advisor. Original research under the supervision of a designated faculty member. The final product must be a written thesis approved by three faculty members: the student's primary advisor, another from the program and one other faculty member. Once registration for thesis has begun, a student must continue to register for a minimum 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

EVSC 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in EVSC 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EVSC 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (EVSC 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EVSC 702. Special Topics in Environmental Science II. 3 credits, 3 contact hours.
Restriction: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EVSC 711. Advanced Environmental Analysis. 3 credits, 3 contact hours.
Prerequisite: EVSC 612 or equivalent. Analysis of complex environmental samples is studied, from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis and data handling. Collection and analysis of samples from air, water, soil, and biological systems will be discussed. Emphasis on the study of current literature.

EVSC 712. Hazardous Substance Management. 3 credits, 3 contact hours.
Restriction: Graduate standing. The course material comprises an overview of hazardous materials and hazardous waste management and control in an industrial setting. The course examines the technical approaches utilized in the control, remediation, and prevention of hazardous substances and waste. It also includes the major technical elements of federal regulations that govern operations involving the handling of hazardous materials.

EVSC 715. Energy and Sustainability. 3 credits, 3 contact hours.
This course comprises an interdisciplinary review of energy fundamentals including the basic principles necessary to understand energy systems. The technological and engineered systems for processing and using different energy non-renewable and renewable sources. The social and environmental consequences of energy production, distribution, and use, including a comparison of socioeconomic models of global energy applications.

EVSC 717. Mass Spectrometry and Mass Spectral Interpretation. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM 126 or equivalent. CHEM 717 and EVSC 617 are comprised of CHEM 717 and EVSC 617 plus a research project: Research projects usually comprise experimental and mass spectrometry interpretation studies. These can be performed at NJIT or in the students corporate mass spectrometry facility. Projects may also include theory, data interpretation or literature reviews pertinent to a current active area in mass spectrometry research. Projects should be approved or in consult with the instructors.

EVSC 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

EVSC 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for EVSC 726 if they have taken EVSC 725 in a prior semester.

EVSC 790. Doctoral Dissertation. 0 credits, 0 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Co-requisite: EVSC 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science. For PhD students who have successfully defended their dissertation proposal. The student must register in EVSC 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

EVSC 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Co-requisite: EVSC 791. Since the EVSC 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

EVSC 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: EVSC 791. Since the EVSC 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in environmental science. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

EVSC 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 790F. Doctoral Dissertation. 15 credits, 15 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all environmental science graduate students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

EVSC 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: EVSC 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in environmental science. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

HIST 600. History Reseach Seminar. 3 credits, 3 contact hours.
This seminar course introduces students to various methods for conducting historical research using primary and secondary source materials, and teaches them how to write a formal research paper. The seminars are on a particular topic chosen by the professor, and can focus on a chronological period or geographic region, on an historical event, cultural movement, or social group, or on a type of history such as environmental history, the history of technology, or the history of health and medicine.

HIST 620. City and Disease in History. 3 credits, 3 contact hours.
Explores the dynamic interaction between the growth of cities and changes in the experience and location of disease. Presumes the intertwining of these two historical developments in the birth of a distinctly urban identity, one predicated on the notion that the modern city is somehow inherently diseased. Focuses on the New York and Newark metropolitan areas in the nineteenth and twentieth centuries. Among the topics considered are epidemic outbreaks, quarantines, the technology and organization of sanitation and hygiene, the professional formation of public, industrial and occupational medicine, and medical and popular responses to immigration.

HIST 622. Culture and Science in the History of American Medicine. 3 credits, 3 contact hours.
Provides an overview of American medical history and a familiarity with the theoretical and practical ramifications of different approaches to the complex relationships between medicine, science, and culture. Topics include: the extent to which medicine is or has been scientific; reasons why science has been considered so important to medicine's professional culture; and the degree to which medicine's professional culture has been shaped by science as well as other factors, such as economic and political self-interest, technology, class, race, gender, and other kinds of cultural values.

HIST 624. Technology, Environment and Medicine in World History, 1500-1900. 3 credits, 3 contact hours.
Examines the interrelationship between the emerging modern world system and changes in technology, environment, and medicine, with particular emphasis on European overseas expansion and its impact in non-Western regions.

HIST 626. Social History of American Medicine Since 1800. 3 credits, 3 contact hours.
Topics include the practices of 19th-century regular medicine; the relation between medical concepts and mainstream social thought; the treatment of women's health; antebellum alternative healers and alternative politics; the triumphs of late 19th- and early 20th-century medical therapeutics; the emergence of medicine as big business; medicine and racism; the emergence of nursing as a profession; modern medicine in an international perspective; New Age healing; the AIDS crisis and AIDS activism; and contemporary debates on the future of health care in the United States.

HIST 628. Gender, Science and Technology in the Modern World. 3 credits, 3 contact hours.
Introduction to a wide range of political and cultural analyses of science and technology, with an emphasis on recent feminist critiques of science. Explores the questions of scientific neutrality; the gendering of scientific knowledge; the relationship between science, technology, and capitalism; the role of science in international politics; and why science has not freed women.

HIST 630. History of the Body in Modern Western Culture. 3 credits, 3 contact hours.
Considers medical or scientific history primarily in terms of implications for bodily experience in everyday life. Begins with grand narratives of historical shifts in bodily perceptions and practices, and proceeds to more focused narratives of changing bodily experience, engaging key distinctions between genders, classes, and species as well as perceptions of pain and internal bodily structure. Materials will be drawn from early modern and modern Europe, as well as more recent bodily experience in the United States.

HIST 632. Global Hist of Tech & Culture. 3 credits, 3 contact hours.
Treats the relationship between technology and cultural values in a variety of historical and geographical settings, from early modern Japan to twentieth-century America. Examines the ways in which cultural ideals, conceptions, and preconceptions serve to influence the rate and manner of technological change, as well as the ways in which technology affects social and cultural life.

HIST 634. Environmental History of North America. 3 credits, 3 contact hours.
Explores the dialogue between humankind and the environment in North America over the course of the last four centuries. Examines the latest and most interesting work done in the new field of environmental history to see what such a perspective has to offer.

HIST 635. History of Technology, Environment and Medicine: Theory and Method. 3 credits, 3 contact hours.
A team-taught course which surveys the methods employed in the three fields. Explores the interdisciplinary nature of each field, and the value of interdisciplinary scholarship.

HIST 637. Global Environmental History. 3 credits, 3 contact hours.
This course takes a global view of human interaction with the natural world, mixing broad themes such as colonialism and industrialization with detailed case studies in an effort ot understand the ways that people and the environment have mutually shaped one another. Because environmental change often transcends national boundaries, this course places important subjects in environmental history such as disease, agriculture, pollution, and environmentalism into a global and transnational context.

HIST 638. Social History of Communication. 3 credits, 3 contact hours.
Treats selected themes in the history of communication in different social and cultural contexts, from the ancient world to the twentieth century. Topics include: orality, proto-literacy, and literacy in ancient and medieval cultures; printing and the development of print culture in the early modern world; the ?communication revolution? of the late 19th and early 20th centuries; and historiographical debates over the role of communication technologies in society.

HIST 640. The Urban Environment. 3 credits, 0 contact hours.
Examines the role of the economy, culture, and technology in shaping the urban environment. Makes extensive use of Newark and the New York metropolitan area, including field observations and local research. In addition to other topics, explores in detail spatial relationships, the role of transportation, and the development of suburbia.

HIST 642. The History of Health and International Development. 3 credits, 3 contact hours.
This course examines the history of western efforts to promote health and nutrition in the 'developing world" from the beginnings of tropical medicine. We will trace this history through its many permutations from the establishment of colonial health services to the development of the Global Programme on AIDS. In doing so, we will explore the various economic and political interests and underlying cultural assumptions that have shaped the development of ideas and practices associated with international health and development.

HIST 644. War, Technology and Society, 1500-1914. 3 credits, 3 contact hours.
Examines key themes in the interrelationship between warfare, technology and society from the beginnings of modern warfare until World War I. Primary emphasis placed on the historical connections between violent conflict, the technical means by which it is carried out, and the socio-political environment within which wars take place. The effect of technology upon war and considerations of the effect of war on technological change and development. Samples the rich tradition of thought and ideas produced by philosophers and theorists on these themes.

HIST 645. American Legal History to 1860. 3 credits, 3 contact hours.
Readings and discussion on the legacy of common law after the Revolution; the emergence of legal instrumentalism; and the evolution of tort, contract, and damages in the context of industrialism and economic growth.

HIST 650. History of American Conservatism. 3 credits, 3 contact hours.
This course examines postwar American conservatism through classic works and contemporary studies. Topics include the rise of conservatism, groups under the conservative umbrella, and the rise of the right as related to key events in postwar history (Cold War, McCarthysim, the '60s, the suburbs and urban change). Course interrogates postwar conservatism with respect to American political and intellectual history and in relation to histories of gender, race, class, sexuality, place and religion.

HIST 652. Topics in the History of Technology. 3 credits, 3 contact hours.
Selected topics in the history of technology.

HIST 653. Topics in European Intellectual and Cultural History. 3 credits, 3 contact hours.
Examination of issues and methods in European intellectual and cultural history, with a consideration of some leading problems in the field.

HIST 654. Topics in American Intellectual and Cultural History. 3 credits, 3 contact hours.
Examination of issues and methods in American intellectual and cultural history, with a consideration of some leading problems in the field.

HIST 655. Topics in American Urban and Ethnic History. 3 credits, 3 contact hours.
Examination of issues and methods in American urban and ethnic history, with a consideration of some leading problems in the field.

HIST 656. Topics in the History of Health. 3 credits, 3 contact hours.
Selected topics in the history of Health.

HIST 657. Topics in Environmental History. 3 credits, 3 contact hours.
Selected topics in environmental history.

HIST 658. Topics in American Legal History. 3 credits, 3 contact hours.
Readings and discussion on the growth of legal formalism, the evolution of substantive due process, changes in legal education and the legal profession, and the evolution of private law.

HIST 660. The Enlightenment in Britain. 3 credits, 3 contact hours.
The 18th century was the age of the Enlightenment. Great Britain became a unified polity and the most powerful imperial force in the world. We examine the Enlightenment in Britain against the backdrop of war and empire, imperial consumer culture, the growth and significance of sociability and politeness, representations of gender, the writing of cultural history, social uses of science/technology, print culture, and competition among varying notions of ethnic identity.

HIST 661. Problems and Readings in European History since 1850. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in European history since 1850.

HIST 662. Prob. and Read: Hist/US Foreighn Policy and Diplomacy. 3 credits, 3 contact hours.
Examination of issues and methods in American diplomatic history, with a consideration of some leading problems in the field.

HIST 663. Problems and Readings in American History, 1492-1789. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history rom 1492 to 1789.

HIST 664. Problems and Readings in American History, 1789-1865. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history from 1789 to 1865.

HIST 665. Problems and Readings in American History, 1865-1914. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history from 1865 to 1914.

HIST 666. Problems and Readings in American History, 1890-1945. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literatue in American history from 1890 to 1945.

HIST 667. Problems and Readings in American History, 1945-Present. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history since 1945.

HIST 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

HIST 701B. Master'S Thesis. 3 credits, 3 contact hours.
Restriction: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

HIST 701C. Master'S Thesis. 6 credits, 6 contact hours.
Restriction: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

HIST 702. Master's Essay. 3 credits, 3 contact hours.
For those who don't write a 6 credit thesis, the 3 credit Master's Essay caps the M.A./M.A.T. A substantial work done with an advisor, may be: 1. Interpretive historical essay based on primary source research. 2. Narrative history based on primary source research. Prereq: R510:504, R510:505, or R510:506. 3. Historiographical essay. 4. Content-focused curriculum design, either a course or significant portion thereof. 5. Design for an historical museum exhibition/other work in public history. Prereq: R510:565.

HIST 725. Independent Study. 3 credits, 1 contact hour.
Restriction: permission of graduate history advisor and course instructor.

HIST 726. Independent Study. 3 credits, 1 contact hour.
Restriction: permission of graduate history advisor and course instructor.

HIST 727. Independent Study. 3 credits, 3 contact hours.
Restriction: permission of graduate history advisor and course instructor.

HIST 791. Seminar in History of Technology, Environment and Medicine. 0 credits, 0 contact hours.
Faculty, students and invited speakers present and discuss current topics of research in history, technology and medicine.

MATH 545. Introductory Mathematical Analysis. 3 credits, 3 contact hours.
Prerequisite: MATH 211 or MATH 213, and departmental approval. Rigorous treatment of the calculus of real-valued functions of one real variable: the real number system, epsilon-delta theory of limit, continuity, derivative, and the Riemann integral. The fundamental theory of calculus. Series and sequences including Taylor series and uniform convergence. The inverse and implicit function theorems.

MATH 546. Advanced Calculus. 3 credits, 3 contact hours.
Prerequisite: MATH 545 or MATH 480. Rigorous treatment of the calculus of real-valued functions of several real variables: the geometry and algebra of n-dimensional Euclidean space, limit, continuity, derivative, and the Riemann integral of functions of several variables, the inverse and implicit function theorems, series, including Taylor series, optimization problems, integration on curves and surfaces, the divergence and related theorems.

MATH 573. Intermediate Differential Equations. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 337, or departmental approval. Methods and applications for systems of ordinary differential equations: existence and uniqueness for solutions of ODEs, linear systems, stability analysis, phase plane and geometrical methods, Sturm-Liouville eigenvalue problems.

MATH 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisites: Graduate status, departmental approval, and permission of the Division of Career Development Services. Cooperative education/ internship providing on-the-job complement to academic programs in mathematics. Work assignments and projects are developed by the Co-op Office in consultation with the Department of Mathematical Sciences.

MATH 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

MATH 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisites: Graduate status, departmental approval, and permission of the Division of Career Development Services.

MATH 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

MATH 599. Teaching in Mathematics. 3 credits, 3 contact hours.
Required of all master's and doctoral students in Mathematical Sciences who are receiving departmental or research-based awards. Provides students with the skills needed to communicate effectively and to perform their teaching and related duties. Students are exposed to strategies and methods for communicating and for teaching undergraduate mathematics, and they are required to practice and demonstrate these techniques. Not counted for degree credit.

MATH 604. Mathematical Finance. 3 credits, 3 contact hours.
Prerequisites: FIN 641 Derivatives, MATH 605 Stochastic Calculus, or permission of the instructor. This course will explore the structure, analysis, and use of financial derivative instruments deployed in investment strategies and portfolio risk management. Topics include continuous time dynamics, arbitrage pricing, martingale methods, and valuation of European, American, and path dependent derivatives.

MATH 605. Stochastic Calculus. 3 credits, 3 contact hours.
This course provides an introduction to stochastic calculus. Topics include conditioning, Poisson processes, martingales, Brownian motion, Ito integrals, Ito's formula, stochastic differential equations, Feynman-Kac formula, Girsanov's theorem, and the martingale representation theorem. Financial applications include pricing, hedging, and interest rate models.

MATH 606. Term Structure Models. 3 credits, 3 contact hours.
Prerequisites: MATH 605, or permission of the instructor. Corequisite: MATH 608. This course will develop the mathematical structure of interest rate models and explore the considerable hurdles involved in practical implementation. Short rate models, single and multifactor; the Heath-Jarrow-Morton framework; and modern Libor market models will be examined.

MATH 607. Credit Risk Models. 3 credits, 3 contact hours.
Prerequisites: MATH 604, MATH 605, MATH 606 or permission of the instructor. This course explores mathematical models and methods for credit risk measurement and rating. The nature of credit risk is reviewed through examination of credit instruments, including credit default swaps, collateralized debt obligations, and basket credit derivatives. These instruments, through which risk exposure opportunities and hedging possibilities are created and managed, are explored with respect to dynamics and valuation techniques, applying PDE methods and stochastic processes.

MATH 608. Partial Differential Equations for Finance. 3 credits, 3 contact hours.
This course presents the subject of partial differential equations (PDE's) with a strong emphasis on the PDE's arising in the study of stochastic processes and finance. The focus is on analytical and numerical methods for obtaining solutions in a form useful for solving problems in financial engineering. Topics include modeling with PDE's, classification of PDE's, analytical and numerical methods for PDE's and application to finance.

MATH 609. Projects in Mathematical and Computational Finance. 3 credits, 3 contact hours.
Prerequisites: MATH 604 Mathematical Finance, MATH 605 Stochastic Calculus, MATH 606 Term Structure Models, or permission of the instructor. This project course requires students to demonstrate attained mastery of the material studies in the prerequisite courses. Projects also extend students? knowledge of specific areas beyond that covered in earlier courses into areas such as particle filtering or optimization techniques for term structure model calibration. The aim is to broaden the students? classroom focus to the more unconstrained, open ended and less well defined contexts that are frequently encountered in practice.

MATH 610. Graduate Research Methods. 3 credits, 0 contact hours.
Prerequisites: MATH 614, MATH 671, and MATH 690. Acquaints second-year graduate students with the techniques and vocabulary of a field in applied mathematics. Each student contacts a designated faculty member and is given several basic papers or books on a research topic of current interest. The student prepares two lectures on his/her topic to be given at the end of the semester. A sample list of active fields of research includes acoustics, electromagnetic theory, elasticity, fluid dynamics, combustion, and mathematical biology.

MATH 611. Numerical Methods for Computation. 3 credits, 3 contact hours.
This course provides a practical introduction to numerical methods. Numerical solution of linear systems. Interpolation and quadrature. Interative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial and boundary value problems for ODE's. Introduction to numerical solution of PDE's. Applicatons drawn from science, engineering, and finance.

MATH 613. Advanced Applied Mathematics I: Modeling. 3 credits, 3 contact hours.
Prerequisites: MATH 331 and MATH 337, or departmental approval. Concepts and strategies of mathematical modeling are developed by investigation of case studies in a selection of areas. Consistency of a model, nondimensionalization and scaling, regular and singular effects are discussed. Possible topics include continuum mechanics (heat and mass transfer, fluid dynamics, elasticity), vibrating strings, population dynamics, traffic flow, and the Sommerfeld problem.

MATH 614. Numerical Methods I. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 337, MATH 340, and proficiency in a computer language (FORTRAN, C, or C++), or departmental approval. Theory and techniques of scientific computation, with more emphasis on accuracy and rigor than MATH 611. Machine arithmetic. Numerical solution of a linear system and pivoting. Interpolation and quadrature. Iterative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial- and boundary-value problems for systems of ODEs. Applications. The class includes examples requiring student use of a computer.

MATH 615. Approaches to Quantitative Analysis in the Life Sciences. 3 credits, 3 contact hours.
A graduate seminar-style course based around case studies of common data analytic methods used in the life sciences. The case studies are designed to help students who are interested in applications of statistical thinking to biological sciences appreciate the scope of quantitative methods, their underlying concepts, assumptions and limitations. While the mathematics of specific methods are not covered, students of the course will get an understanding of the diverse approaches to statistical inference in the life sciences.

MATH 630. Linear Algebra and Applications. 3 credits, 3 contact hours.
Prerequisites: (This course is not intended for students in the Master's in Applied Mathematics program or in the doctoral program in Mathematical Sciences.) Math 211 or Math 213, and Math 222. Development of the concepts needed to study applications of linear algebra and matrix theory to science and engineering. Topics include linear systems of equations, matrix algebra, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition.

MATH 631. Linear Algebra. 3 credits, 3 contact hours.
Prerequisites: MATH 222 and MATH 337, or departmental approval. Similar in aim and content to MATH 630 but with more emphasis on mathematical rigor. Linear systems of equations, matrix algebra, linear spaces, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition. Applications.

MATH 635. Analytical Computational Neuroscience. 3 credits, 3 contact hours.
Prerequisites: MATH 211 or 213, MATH 337, and CS 113 or MATH 240, or departmental approval. This course will provide an intermediate-level mathematical and computational modeling background for small neuronal systems. Models of biophysical mechanisms of single and small networks of neurons are discussed. Topics include voltage-dependent channel gating mechanisms, the Hodgkin-Huxley model for membrane excitability, repetitive and burst firing, single- and multi-compartmental modeling, synaptic transmission, mathematical treatment of 2-cell inhibitory or excitatory networks. In this course, the students will be required to build computer models of neurons and networks and analyze these models using geometric singular-perturbation analysis and dynamical systems techniques.

MATH 636. Systems Computational Neuroscience. 3 credits, 3 contact hours.
Prerequisite: MATH 635. This course covers mathematical and computational modeling of neuronal networks. Topics covered include central pattern generators, models of visual processes, models of learning and memory, neural coding and mathematics of neural networks, models of oscillations in sensory, thalamic and thalamo-cortical networks, neuronal wave propagation.

MATH 637. Foundations of Mathematical Biology. 3 credits, 3 contact hours.
Prerequisites: MATH 222 and MATH 337, or departmental approval. This course provides an introduction to the use of mathematical techniques applied to solve problems in biology. Models discussed fall into 3 categories: discrete, continuous, and spatially distributed. Biological topics discussed range from the subcellular molecular systems and cellular behavior to physiological problems, population biology and developmental biology.

MATH 639. Mathematical Modeling II. 3 credits, 3 contact hours.
Continuation of MATH 613 (Advanced Applied Mathematics I, Modeling). Concepts and strategies of Mathematical modeling are developed by case studies in a selection of areas. Topics will be complementary to those presented in MATH 613, and include for example, the mathematical theory of elasticity and electromagnetism.

MATH 644. Regression Analysis Methods. 3 credits, 3 contact hours.
Prerequisite: MATH 661. Regression models and the least squares criterion. Simple and multiple linear regression. Regression diagnostics. Confidence intervals and tests of parameters, regression and analysis of variance. Variable selection and model building. Dummy variables and transformations, growth models. Other regression models such as logistic regression. Using statistical software for regression analysis.

MATH 645. Analysis I. 3 credits, 3 contact hours.
Prerequisite: MATH 546 or departmental approval. Review and extension of the fundamental concepts of advanced calculus: the real number system, limit, continuity, differentiation, the Riemann integral, sequences and series. Point set topology in metric spaces. Uniform convergence and its applications.

MATH 646. Time Series Analysis. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or departmental approval. Time series models, smoothing, trend and removal of seasonality. Naive forecasting models, stationarity and ARMA models. Estimation and forecasting for ARMA models. Estimation, model selection, and forecasting of nonseasonal and seasonal ARIMA models.

MATH 647. Time Series Analysis II. 3 credits, 3 contact hours.
Prerequisite: MATH 646. Continuation of MATH 646. Covers methods of time series analysis useful in engineering, the sciences, economics, and modern financial analysis. Topics include spectral analysis, transfer functions, multivariate models, state space models and Kalman filtering. Selected applications from topics such as intervention analysis, neural networks, process control, financial volatility analysis.

MATH 651. Methods of Applied Mathematics I. 3 credits, 3 contact hours.
Prerequisite: MATH 222 or departmental approval. A survey of mathematical methods for the solution of problems in the applied sciences and engineering. Topics include: ordinary differential equations and elementary partial differential equations. Fourier series, Fourier and Laplace transforms, and eigenfunction expansions.

MATH 654. Clinical Trials Design and Analysis. 3 credits, 3 contact hours.
Prerequisites: MATH 665 or equivalent with Departmental approval. Statistical methods and issues in the design of clinical trials and analysis of their data. Topic include clinical trial designs for phases 1-4, randomization principle and procedures, analysis of pharmacokinetic data for bioequivalence, multi-center trials, categorical data analysis, survival analysis, longitudinal data analysis, interim analysis, estimation of sample size and power, adjustment for multiplicity, evaluation of adverse events, and regulatory overview.

MATH 656. Complex Variables I. 3 credits, 3 contact hours.
Prerequisite: MATH 545 or MATH 645 or departmental approval. The theory and applications of analytic functions of one complex variable: elementary properties of complex numbers, analytic functions, elementary complex functions, conformal mapping, Cauchy integral formula, maximum modulus principle, Laurent series, classification of isolated singularities, residue theorem, and applications.

MATH 659. Survival Analysis. 3 credits, 3 contact hours.
Prerequisites: MATH 665 or equivalent with Departmental approval. Introduction to statistical methods for modeling time-to-event data in the presence of censoring and truncation, with emphasis on applications to the health sciences. Topics include survival and hazard functions, censoring and truncation, parametric and nonparametric models for survival data, competing-risks, regression models including Cox proportional hazards model and time-dependent covariates, one and two sample tests, and use of appropriate statistical software for computations.

MATH 660. Introduction to statistical Computing with SAS and R. 3 credits, 3 contact hours.
Prerequisite: Basic knowledge in statistical concepts or instructor approval. This course will study SAS and R programming and emphasize the SAS and R data steps including getting data into the SAS and R environments, working and combining data using control flows, merge and subsets, etc. as well as learning to export data and to generate high resolution graphics. Several SAS and R statistical procedures or functions will also be discussed and illustrated. Finally, interactive statistical software JMP and Minitab are briefly introduced.

MATH 661. Applied Statistics. 3 credits, 3 contact hours.
Prerequisite: MATH 112. Role and purpose of applied statistics. Data visualization and use of statistical software used in course. Descriptive statistics, summary measures for quantitative and qualitative data, data displays. Modeling random behavior: elementary probability and some simple probability distribution models. Normal distribution. Computational statistical inference: confidence intervals and tests for means, variances, and proportions. Linear regression analysis and inference. Control charts for statistical quality control. Introduction to design of experiments and ANOVA, simple factorial design and their analysis. MATH 661 and MATH 663 cannot both be used toward degree credits at NJIT.

MATH 662. Probability Distributions. 3 credits, 3 contact hours.
Prerequisites: MATH 341 or MATH 333, and departmental approval. Probability, conditional probability, random variables and distributions, independence, expectation, moment generating functions, useful parametric families of distributions, transformation of random variables, order statistics, sampling distributions under normality, the central limit theorem, convergence concepts and illustrative applications.

MATH 663. Introduction to Biostatistics. 3 credits, 3 contact hours.
Prerequisite: Undergraduate Calculus. Introduction to statistical techniques with emphasis on applications in health related sciences. This course will be accompanied by examples from biological, medical and clinical applications. Summarizing and displaying data; basic probability and inference; Bayes' theorem and its application in diagonostic testing; estimation, confidence intervals, and hypothesis testing for means and proportions; contingency tables; regression and analysis of variance; logistic regression and survival analysis; basic epidemiologic tools; use of statistical software. Math 661 and Math 663 cannot both be used toward degree credits at NJIT.

MATH 664. Methods for Statistical Consulting. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or departmental approval. Communicating with scientists in other disciplines. Statistical tools for consulting. Using statistical software such as JMP, SAS, and S-plus. Case studies which illustrate using statistical methodology and tools are presented by the instructor and guest speakers from academia and industry. Assignments based on case studies with use of statistical software is required.

MATH 665. Statistical Inference. 3 credits, 3 contact hours.
Prerequisite: MATH 662 or departmental approval. Review of sampling distributions. Data reduction principles: sufficiency and likelihood. Theory and methods of point estimation and hypothesis testing, interval estimation, nonparametric tests, introduction to linear models.

MATH 666. Simulation for Finance. 3 credits, 3 contact hours.
Covers the use of Monte Carlo stochastic simulation for finance applications. Topics include generation of various random variables and stochastic processes (e.g., point processes, Brownian motion, diffusions), simulation methods for estimating quantities of interest (e.g., option prices, probabilities, expected values, quantiles), input modeling, and variance-reduction techniques. Students will write computer programs in C++. Students cannot receive credit for both CS 661 and CS/MATH 666.

MATH 671. Asymptotic Methods I. 3 credits, 3 contact hours.
Prerequisites: MATH 645 or MATH 545, and MATH 656, or departmental approval. Asymptotic sequences and series. Use of asymptotic series. Regular and singular perturbation methods. Asymptotic methods for the solution of ODEs, including: boundary layer methods and asymptotic matching, multiple scales, the method of averaging, and simple WKB theory. Asymptotic expansion of integrals, including: Watson's lemma, stationary phase, Laplace's method, and the method of steepest descent.

MATH 672. Biomathematics I: Biological Waves and Oscillations. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 331, and MATH 337, or departmental approval. Models of wave propagation and oscillatory phenomena in nerve, muscle, and arteries: Hodgkin-Huxley theory of nerve conduction, synchronization of the cardiac pacemaker, conduction and rhythm abnormalities of the heart, excitation-contraction coupling, and calcium induced waves, wave propagation in elastic arteries, models of periodic human locomotion.

MATH 673. Biomathematics II: Pattern Formation in Biological Systems. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 331, and MATH 337, or departmental approval. Emergence of spatial and temporal order in biological and ecological systems: Hopf and Turing bifurcation in reaction-diffusion systems, how do zebras get their stripes, patterns on snake skins and butterfly wings, spatial organization in the visual cortex, symmetry breaking in hormonal interactions, how do the ovaries count. Basic techniques of mathematics are introduced and applied to significant biological phenomena that cannot be fully understood without their use.

MATH 675. Partial Differential Equations. 3 credits, 3 contact hours.
Prerequisite: MATH 690 or departmental approval. A survey of the mathematical theory of partial differential equations: first-order equations, classification of second-order equations, the Cauchy-Kovalevsky theorem, properties of harmonic functions, the Dirichlet principle. Initial- and boundary-value problems for hyperbolic, elliptic, and parabolic equations. Systems of equations.

MATH 676. Advanced Ordinary Differential Equations. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 337, and MATH 545 or MATH 645. A rigorous treatment of the theory of systems of differential equations: existence and uniqueness of solutions, dependence on initial conditions and parameters. Linear systems, stability, and asymptotic behavior of solutions. Nonlinear systems, perturbation of periodic solutions, and geometric theory of systems of ODEs.

MATH 677. Calculus of Variations. 3 credits, 3 contact hours.
Prerequisite: MATH 545 or MATH 645 or departmental approval. Necessary conditions for existence of extrema. Variation of a functional, Euler's equation, constrained extrema, first integrals, Hamilton-Jacobi equation, quadratic functionals. Sufficient conditions for the existence of extrema. Applications to mechanics.

MATH 678. Stat Methods in Data Science. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or MATH 663, or permission by instructor. This course introduces students to concepts in statistical methods used in data science, including data collection, data visualization and data analysis. Emphasis is on model building and statistical concepts related to data analysis methods. The course provides the basic foundational tools on which to pursue statistics, data analysis and data science in greater depth. Topics include sampling and experimental design, understanding the aims of a study, principles of data analysis, linear and logistic regression, resampling methods, and statistical learning methods. Students will use the R statistical software.

MATH 680. Advanced Statistical Learning. 3 credits, 3 contact hours.
Prerequisites: MATH 478 or MATH 678, or permission by instructor. This course builds on the material in MATH 478 or MATH 678 and serves as a second graduate course in data science with emphasis on statistics. It covers many topics in high dimensional data analysis, including LASSO, SCAD and other regularization procedures, sparse PCA, sparse k-means, and asymptotic theory for high dimensional models. This course will provide students with necessary theoretical and computational skills to understand, design, and implement modern statistical learning methods, including ensemble learning (bagging, random forest, and boosting). Students will use the R statistical software.

MATH 683. High Dimensional Stat Inferenc. 3 credits, 3 contact hours.
Prerequisite: MATH 665 or permission by instructor. This course introduces modern statistical inference theory and methods developed as a result of the influence of computing. The course covers statistical thinking, ideas and theory that underlie many of the statistical learning algorithms used in data science, such as bootstrap, EM algorithm, cross-validation, large-scale hypothesis test, false discovery rates, sparse modeling, support vector machines and ensemble learning.

MATH 687. Quantitative Analysis for Environmental Design Research. 3 credits, 3 contact hours.
Prerequisites: MATH 333 and departmental approval. Fundamental concepts in the theory of probability and statistics including descriptive data analysis, inferential statistics, sampling theory, linear regression and correlation, and analysis of variance. Also includes an introduction to linear programming and nonlinear models concluding with some discussion of optimization theory.

MATH 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
Prerequisites: MATH 111, MATH 112 and (MATH 211 or MATH 213). The course introduces mathematical methods necessary for materials science with emphasis on practical applications. Topics include power series, complex numbers, linear algebra, partial differentiation, multiple integrals, vector analysis, Fourier series and transformation, ordinary and partial differential equations, functions of complex variables, probability, and statistics.

MATH 689. Advanced Applied Mathematics II: Ordinary Differential Equations. 3 credits, 3 contact hours.
Prerequisites: MATH 545 or MATH 645, MATH 613, and MATH 631. A practical and theoretical treatment of boundary-value problems for ordinary differential equations: generalized functions, Green's functions, spectral theory, variational principles, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

MATH 690. Advanced Applied Mathematics III: Partial Differential Equations. 3 credits, 3 contact hours.
Prerequisite: MATH 689. A practical and theoretical treatment of initial- and boundary-value problems for partial differential equations: Green's functions, spectral theory, variational principles, transform methods, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

MATH 691. Stochastic Processes with Applications. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Renewal theory, renewal reward processes and applications. Homogeneous, non-homogeneous, and compound Poisson processes with illustrative applications. Introduction to Markov chains in discrete and continuous time with selected applications.

MATH 692. MSMCF Forum. 0 credits, 0 contact hours.
Forum comprises informal discussions and debates engaging students in the realities of living and working in the world, with a focus on economics and finance. These realities include broad awareness of contemporary events, ethical implications of decisions, proper implementation and use of models, the research process and the critical skills of communication. Forum meetings are designed to promote understanding and build experience in all these areas.

MATH 698. Sampling Theory. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Role of sample surveys. Sampling from finite populations. Sampling designs, the Horowitz-Thompson estimator of the population mean. Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.

MATH 699. Design and Analysis of Experiments. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Statistically designed experiments and their importance in data analysis, industrial experiments. Role of randomization. Fixed and random effect models and ANOVA, block design, latin square design, factorial and fractional factorial designs and their analysis.

MATH 700. Master's Project. 0 credits, 0 contact hours.
Prerequisites: Matriculation for the Master of Science in Applied Mathematics or in Applied Statistics and departmental approval. Work must be initiated with the approval of a faculty member, who will be the student's project advisor. Work of sufficient quality may qualify for extension into a master's thesis, see Math 701.

MATH 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied mathematics or applied statistics. A written report must be submitted to the project advisor. The student cannot register in MATH 700B more than once and the incomplete (I) grade is not allowed.

MATH 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: Matriculation for the master's degree and departmental approval. Students must register for a minimum of 3 credits per semester until completion. The work is carried out under the supervision of a designated member of the faculty.

MATH 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied mathematics or applied statistics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in MATH 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MATH 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied mathematics or applied statistics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (MATH 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MATH 707. Advanced Applied Mathematics IV: Special Topics. 3 credits, 3 contact hours.
Prerequisite: Departmental approval. A current research topic of interest to departmental faculty. Typical topics include: computational fluid dynamics, theoretical fluid dynamics, acoustics, wave propagation, dynamical systems, theoretical and numerical aspects of combustion, mathematical biology, and various topics in statistics.

MATH 712. Numerical Methods II. 3 credits, 3 contact hours.
Prerequisites: MATH 614, MATH 331 or departmental approval, and proficiency in a computer programming language (FORTRAN, C, or C++). Numerical methods for the solution of initial- and boundary-value problems for partial differential equations, with emphasis on finite difference methods. Consistency, stability, convergence, and implementation are considered.

MATH 713. Advanced Scientific Computing: Multi-Dimensional Finite-Difference Schemes and Spectral Methods. 3 credits, 3 contact hours.
Prerequisites: MATH 712 and proficiency in a computer programming language (FORTRAN, C, or C++). Derivation and analysis of finite difference schemes for systems of partial differential equations in two and three spatial dimensions and time. Issues pertaining to efficient implementation of algorithms and to stability of physical and numerical boundary conditions. Pseudo-spectral and spectral methods to solve partial differential equations. Approximation properties of Fourier and Chebyshev series and techniques based on the Fast Fourier Transform (FFT) and on matrix multiplication to numerically compute partial derivatives. Time-discretization techniques suitable for use with pseudo-spectral and spectral methods. Model systems arising in wave propagation, fluid dynamics, and mathematical biology will be considered.

MATH 715. Mathematical Fluid Dynamics I. 3 credits, 3 contact hours.
Introduction to the basic ideas of fluid dynamics, with an emphasis on rigorous treatment of fundamentals and the mathematical developments and issues. The course focuses on the background and motivation for recent mathematical and numerical work on the Euler and Navier-Stokes equations, and presents a mathematically intensive investigation of various model equations of fluid dynamics (e.g., the Korteweg-de-Vries equations).

MATH 716. Mathematical Fluid Dynamics II. 3 credits, 0 contact hours.
Continuation of MATH 715. Further development of the ideas of fluid dynamics, with an emphasis on mathematical developments and issues. A selection of topics will be developed in some detail, for example: Stokes flow and low-Reynolds-number hydrodynamics; flow at high Reynolds number and boundary layers; shock waves and hyperbolic systems; dynamics of interfacial flows; hydrodynamic stability; rotating fluids.

MATH 717. Inverse Problems and Global Optimization. 3 credits, 3 contact hours.
Introduction to inverse problems and global optimization. Linear, quasi-linear, and nonlinear inverse problems are studied with emphasis on regularization techniques. Bayesian statistical approaches and Monte Carlo methods are introduced and discussed in the context of inverse problems. The mathematical foundations of simulated annealing, genetic algorithms, and TABU are presented.

MATH 720. Tensor Analysis. 3 credits, 3 contact hours.
Prerequisites: MATH 613 and MATH 631, or departmental approval. Review of vector analysis in general curvilinear coordinates. Algebra and differential calculus of tensors. Applications to differential geometry, analytical mechanics, and mechanics of continuous media. The choice of applications will be determined by the interests of the class.

MATH 722. Wave Propagation. 3 credits, 3 contact hours.
Derivation of linear wave equations describing acoustic, electromagnetic, elastodynamic and hydrodynamic phenomena. Fundamental solutions and their application to initial value problems. Applications and solution of boundary value problems using Green's functions, image and spectral methods. Related time harmonic problems, including radiation, scattering, diffraction and transmission phenomena. Dispersive waves and the method of stationary phase. Linear waves in anisotropic media.

MATH 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

MATH 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for MATH 726 if they have taken MATH 725 in a prior semester.

MATH 745. Analysis II. 3 credits, 3 contact hours.
Prerequisite: MATH 645. Lebesgue measure and integration, including the Lebesgue dominated convergence theorem and Riesz-Fischer theorem. Elements of Hilbert spaces and Lp-spaces. Fourier series and harmonic analysis. Multivariate calculus.

MATH 756. Complex Variables II. 3 credits, 3 contact hours.
Prerequisite: MATH 656. Selected topics from: conformal mapping and applications of the Schwarz-Christoffel transformation, applications of calculus of residues, singularities, principle of the argument, Rouche's theorem, Mittag-Leffler's theorem, Casorati-Weierstrass theorem, analytic continuation, and applications, Schwarz reflection principle, monodromy theorem, Wiener-Hopf technique, asymptotic expansion of integrals; integral transform techniques, special functions.

MATH 761. Statistical Reliability Theory and Applications. 3 credits, 3 contact hours.
Prerequisite: MATH 662 or departmental approval. Survival distributions, failure rate and hazard functions, residual life. Common parametric families used in modeling life data. Introduction to nonparametric aging classes. Coherent structures, fault tree analysis, redundancy and standby systems, system availability, repairable systems, selected applications such as software reliability.

MATH 763. Generalized Linear Models. 3 credits, 3 contact hours.
Prerequisites: MATH 662 and MATH 665 or departmental approval. Theoretical and applied aspects of generalized linear models. Classical linear models, nonlinear regression models, and generalized estimating equations.

MATH 767. Fast Numerical Algorithms. 3 credits, 3 contact hours.
The course covers state-of-the-art, analysis-based, fast numerical algorithms for computing discrete summations/transforms and for solving differential/integral equations. In particular, this course presents fast multiple methods and their descendants, including fast Fourier transform for nonequispaced data, fast Gauss transform, fast iterative solver and direct solver for elliptic boundary value problems.

MATH 768. Probability Theory. 3 credits, 3 contact hours.
Prerequisite: MATH 645 or departmental approval. Measure theoretic introduction to axiomatic probability. Probability measures on abstract spaces and integration. Random variables and distribution functions, independence, 0-1 laws, basic inequalities, modes of convergence and their interrelationships, Laplace-Stieltjes transforms and characteristic functions, weak and strong laws of large numbers, conditional expectation, discrete time martingales.

MATH 771. Asymptotic Methods II. 3 credits, 3 contact hours.
Prerequisite: MATH 671. Continuation of MATH 671. Asymptotic methods for the solution of PDEs, including: matched asymptotic expansions, multiple scales, the WKB method or geometrical optics, and near-field far-field expansions. Applications to elliptic, parabolic, and hyperbolic problems. Further topics in the asymptotic expansion of integrals and the WKB method. Emphasis on examples drawn from applications in science and engineering.

MATH 786. Large Sample Theory and Inference. 3 credits, 3 contact hours.
Prerequisites: MATH 665 and MATH 768. Limit theorems, central limit theorem, asymptotic expansions and large deviations, limit theorems in martingales and semi-martingales and stochastic differential equations, asymptotic expansions of functions of statistics, linear parametric estimation, asymptotic efficiency, martingale approach to inference: test for homogeneity and goodness of fit, decomposable statistics, inference for counting processes and censored data, inference in nonlinear regression, existence and consistency of least squares estimator (LSE), asymptotic properties of LSE, Von Mises functionals, estimation of parameters of stable laws, empirical characteristics function for inference, generalized least squares for linear models.

MATH 787. Non-Parametric Statistics. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Wilcoxon signed-ranks test, Mann-Whitney U test, binomial sign test for single sample and two dependent samples, McNemar's test, Cochran Q test, Wilcoxon matched-pairs signed-ranks test, Kruskal-Wallis one-way analysis of variance, Friedman two-way analysis of variance, Siegel-Tukey test for equal variability, chi-squared goodness-of-fit test, test for homogeneity and independence, single-sample runs test and other tests of randomness, correlation tests: Spearman's rank-order correlation, coefficient and Kendall's tau, Kendall's coefficient of concordance, and Goodman and Kruskal's gamma, comparing power efficiency.

MATH 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Prerequisite: Excellent performance on the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Candidates must register for 6 to12 credits per semester, to be determined by a designated dissertation advisor. After reaching 36 credits, students must continue to register for 3 credits each semester until degree completion.

MATH 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: MATH 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mathematical sciences. For PhD students who have successfully defended their dissertation proposal. The student must register in MATH 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

MATH 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: MATH 791. Since the MATH 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in mathematical sciences. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

MATH 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: MATH 791. Since the MATH 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in mathematical sciences. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

MATH 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.
Prerequisite: Excellent performance on the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Candidates must register for 6 to12 credits per semester, to be determined by a designated dissertation advisor. After reaching 36 credits, students must continue to register for 3 credits each semester until degree completion.

MATH 790E. Doctoral Dissertation. 12 credits, 12 contact hours.
Prerequisite: Excellent performance on the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Candidates must register for 6 to12 credits per semester, to be determined by a designated dissertation advisor. After reaching 36 credits, students must continue to register for 3 credits each semester until degree completion.

MATH 791. Graduate Seminar. 0 credits, 1 contact hour.
All master's and doctoral students receiving departmental or research-based awards must register for this course each semester.

MATH 792B. Pre Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: MATH 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in mathematical sciences. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

MATH 792D. Pre Doctoral Research. 9 credits, 9 contact hours.

MTSE 590. Grad Coop Work Exp I. 1 credit, 1 contact hour.

MTSE 591. Grad Coop Work Experience II. 1 credit, 1 contact hour.

MTSE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisites: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

MTSE 601. Fundamentals of Engineering Materials. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Core course for students in Material Science and Engineering. The effect of structure on the properties and behavior of engineering materials. Topics include atomic structure, bonding, crystallography, and defects in solids; properties of metals, semiconductors, ceramics, and polymers and their behavioral response to mechanical, chemical, optical, electrical, and magnetic stimuli.

MTSE 602. Thermodynamics of Materials. 3 credits, 3 contact hours.
Prerequisite: undergraduate thermodyamics. Core course for students in Material Science and Engineering. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MTSE 603. Intro to Phys Prin of Material. 3 credits, 3 contact hours.
Introduction to physical principles useful to understand materials properties. Topics include Schrodinger equations, harmonic oscillators, observables, operators, angular momentum, hydrogen atom, atoms, matrix representation of operators, perturbation theory, molecules, metals, insulators, semiconductors, and low dimensional materials.

MTSE 610. Mechanical Properties of Materials. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Elements of elasticity and plasticity theory, deformation and fracture behavior of materials, the concept of dislocations and their interaction with other lattice defects, strengthening mechanisms in solids, and principles of failure analysis. Materials to be studied include metals, polymers, ceramics, glasses, and composites.

MTSE 615. Composite Materials. 3 credits, 3 contact hours.
Prerequisites: MTSE 605 and MTSE 610. Introduction to fundamental principles of design and technology of composite materials. Materials based on polymer, ceramic, and metal matrices are discussed. Properties of the constitutive materials, their structure, methods of structural arrangements, as well as properties and characterization of the final products are described. The different perspectives, examples, and problems in composite applications are outlined.

MTSE 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy, near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

MTSE 625. Introduction to Ceramics. 3 credits, 3 contact hours.
Prerequisite: MTSE 605. Mechanical, thermal, electrical, magnetic, and optical properties of crystalline and glassy ceramics are discussed from a structural viewpoint. Important processing methods, design and evaluation of properties, and modern applications of ceramic materials are emphasized.

MTSE 627. Glass Science and Engineering. 3 credits, 3 contact hours.
Prerequisites: MTSE 605 and MTSE 630. Formation and structure of inorganic, polymeric, and metallic glasses. Transport phenomena, kinetics of crystallization, glass transition, and phase separation; chemical, mechanical and optical properties of glasses.

MTSE 630. Thermodynamics of Materials. 3 credits, 3 contact hours.
Prerequisite: undergraduate thermodyamics. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MTSE 650. Physical Metallurgy. 3 credits, 3 contact hours.
Prerequisite: MTSE 605. Processing-structure-property relationships in metallic alloys. Alloy systems covered include carbon steels, stainless steels, aluminum and titanium alloys, and super alloys. Topics to be presented include elementary theory of metals, defects and related phenomena, solidification, phase phenomena, solid state diffusion, nucleation and growth kinetics, as well as transformation and deformation processes.

MTSE 655. Diffusion and Solid State Kinetics. 3 credits, 3 contact hours.
Prerequisite: MTSE 630. The atomic theory of diffusion and mathematical derivation of the diffusion equations. Diffusion phenomena in dilute alloys as well as in ionic and covalent solids are considered. High atom mobility effects at defect sites and surfaces are examined. Chemical kinetics and kinetics of phase transformations including nucleation, growth, and spinodal decomposition are discussed.

MTSE 681. Composite Materials. 3 credits, 3 contact hours.
Prerequisites: MTSE 601 and MTSE 610. Introduction to fundamental principles of design and technology of composite materials. Materials based on polymer, ceramic, and metal matrices are discussed. Properties of the constitutive materials, their structure, methods of structural arrangements, as well as properties and characterization of the final products are described. The different perspectives, examples, and problems in composite applications are outlined.

MTSE 682. Introduction to Ceramics. 3 credits, 3 contact hours.
Prerequisite: MTSE 601. Mechanical, thermal, electrical, magnetic, and optical properties of crystalline and glassy ceramics are discussed from a structural viewpoint. Important processing methods, design and evaluation of properties, and modern applications of ceramic materials are emphasized.

MTSE 685. Physical Metallurgy. 3 credits, 3 contact hours.
Prerequisite: MTSE 601. Processing-structure-property relationships in metallic alloys. Alloy systems covered include carbon steels, stainless steels, aluminum and titanium alloys, and super alloys. Topics to be presented include elementary theory of metals, defects and related phenomena, solidification, phase phenomena, solid state diffusion, nucleation and growth kinetics, as well as transformation and deformation processes.

MTSE 687. Glass Science and Engineering. 3 credits, 3 contact hours.
Prerequisites: MTSE 601 and MTSE 602. Formation and structure of inorganic, polymeric, and metallic glasses. Transport phenomena, kinetics of crystallization, glass transition, and phase separation; chemical, mechanical and optical properties of glasses.

MTSE 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
Prerequisites: MATH 111, MATH 112 and (MATH 211 or MATH 213). The course introduces mathematical methods necessary for materials science with emphasis on practical applications. Topics include power series, complex numbers, linear algebra, partial differentiation, multiple integrals, vector analysis, Fourier series and transformation, ordinary and partial differential equations, functions of complex variables, probability, and statistics.

MTSE 690. Directed Study in Materials Science and Engineering. 3 credits, 3 contact hours.
Prerequisite: As specified by the instructor. Directed study at the Master's level under the guidance of a faculty member on a topic in materials science and engineering.

MTSE 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisites: sufficient experience and/or graduate courses to work on the project and approval of project advisor. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Students may extend the master's project into a master's thesis.

MTSE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science. A written report must be submitted to the project advisor. The student cannot register in MTSE 700B more than once and the incomplete (I) grade is not allowed.

MTSE 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: sufficient experience and/or graduate courses to work on the thesis and approval of thesis advisor. Research involving experimental or theoretical investigations or collaborative projects with industry or governmental agencies may be accepted. Completed work in the form of a written thesis should merit publication in a technical journal and must be approved by a committee consisting of three faculty members. A student must register for 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

MTSE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in MTSE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MTSE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (MTSE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MTSE 702. Characterization of Solids. 3 credits, 3 contact hours.
Current methods for characterizing the chemical composition, crystallographic structure, electrical mapping, and morphology of solid materials. Principles and application of Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), X-ray Photoelectron Spectroscopy (XPS), X-ray Emission Spectroscopy (XES), and Rutherford Backscattering Spectroscopy (RBS) for chemical analysis, X-ray Diffraction (XRD) and electron diffraction for crystallographic analysis, Electron Beam Induced Current (EBIC) microscopy, voltage contrast microscopy, Cathodoluminescence for electrical mapping, and Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) and Nomarski interference contrast microscopy (DIC) for morphology.

MTSE 719. Physical Principles of Characterization of Solids. 3 credits, 3 contact hours.
Core course for students in Material Science and Engineering, Nano-scale characterization of materials. Basic science behind solid state characterization. Elements of modern physics. Optical microscope. Neutron scattering. Infrared and Raman spectroscopy. Rutherford backscattering spectroscopy. NMR. X-ray diffraction. X-ray photoelectron spectroscopy and Auger Electron Spectroscopy. SEM, TEM, STEM and STM.

MTSE 722. Science and Technology of Thin Films. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Methods of preparing thin films by physical and chemical means are examined. Topics pertinent to nucleation and growth mechanism of single and polycrystalline films, structure determination, film thickness and compositional evaluation properties are discussed. The electrical, magnetic, optical, and mechanical properties of metallic, semiconductor, and insulating thin films are studied with particular relevance to integrated circuit applications.

MTSE 723. Defects in Solids. 3 credits, 3 contact hours.
Prerequisites: MTSE 601 and MTSE 725. Crystallographic defects in solids, namely point defects such as vacancies and interstitial, line defects such as dislocations, and planar defects such as grain boundaries. Correlation of these defects to the mechanical, electrical and optical behavior of materials is examined in particular. Experimental methods for observation and characterization of defects including TEM, EBIC, DLTS are described.

MTSE 724. Transport of Electrons and Phonons in Solids. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 or R755 687. Basic transport processes involving electrons and phonons in solids. Topics inlcude transport-related phenomena such as Hall effect, quantum Hall effect, magneto-resistance, size effects, thermal conductivity, thermoelectric effects, phonon drag, ballistic phonons, and ballistic electrons. Applications of transport to the characterization of new electronic materials including thin films are stressed.

MTSE 725. Crystallography and Diffraction. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

MTSE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for MTSE 726 if they have taken MTSE 725 in a prior semester.

MTSE 737. Transport of Electrons and Phonons in Solids. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 or R755 687. Basic transport processes involving electrons and phonons in solids. Topics inlcude transport-related phenomena such as Hall effect, quantum Hall effect, magneto-resistance, size effects, thermal conductivity, thermoelectric effects, phonon drag, ballistic phonons, and ballistic electrons. Applications of transport to the characterization of new electronic materials including thin films are stressed.

MTSE 757. Defects in Solids. 3 credits, 3 contact hours.
Prerequisites: MTSE 605 and MTSE 725. Crystallographic defects in solids, namely point defects such as vacancies and interstitial, line defects such as dislocations, and planar defects such as grain boundaries. Correlation of these defects to the mechanical, electrical and optical behavior of materials is examined in particular. Experimental methods for observation and characterization of defects including TEM, EBIC, DLTS are described.

MTSE 765. Science and Technology of Thin Films. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Methods of preparing thin films by physical and chemical means are examined. Topics pertinent to nucleation and growth mechanism of single and polycrystalline films, structure determination, film thickness and compositional evaluation properties are discussed. The electrical, magnetic, optical, and mechanical properties of metallic, semiconductor, and insulating thin films are studied with particular relevance to integrated circuit applications.

MTSE 780. Current Topics in Materials Science and Engineering. 3 credits, 3 contact hours.
Prerequisites: As specified by the program for the semester's offering. Topics of current interest in materials science and engineering.

MTSE 788. Appl Comp Meth-Phys & Matls II. 3 credits, 3 contact hours.

MTSE 790. Doc Dissertation & Res. 0 credits, 0 contact hours.
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for 6 credits each semester until 36 credits are reached. If the dissertation is not yet complete, registration for an additional 3 credits is required each semester thereafter.

MTSE 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Co-requisite: MTSE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science. For PhD students who have successfully defended their dissertation proposal. The student must register in MTSE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

MTSE 790B. Doc Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: MTSE 791. Since the MTSE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

MTSE 790C. Doc Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: MTSE 791. Since the MTSE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in materials science. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

MTSE 790D. Doc Dissertation & Res. 9 credits, 9 contact hours.
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for 6 credits each semester until 36 credits are reached. If the dissertation is not yet complete, registration for an additional 3 credits is required each semester thereafter.

MTSE 790E. Doct Dissertation & Resrch. 12 credits, 12 contact hours.
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for 6 credits each semester until 36 credits are reached. If the dissertation is not yet complete, registration for an additional 3 credits is required each semester thereafter.

MTSE 790F. Doct Disrtn & Research. 15 credits, 3 contact hours.
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for 6 credits each semester until 36 credits are reached. If the dissertation is not yet complete, registration for an additional 3 credits is required each semester thereafter.

MTSE 790G. Doctrl Dissrtn & Resrch. 18 credits, 3 contact hours.

MTSE 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all students enrolled in the M.S. or Ph.D. Program in Materials Science and Engineering. Faculty, students, and invited speakers will present and discuss current topics of research in materials science and engineering.

MTSE 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: MTSE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in materials science. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

MTSE 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

OPSE 601. Advanced Topics in Optical Science and Engineering. 3 credits, 3 contact hours.
In small groups or as an individual, students conduct three complete research experiments in the available topics of interest, from preliminary background research through data analysis. Use of modern optical research tools under close guidance of faculty and associated research team members in the faculty member's lab.

OPSE 610. Virtual Instrumentation. 3 credits, 3 contact hours.
Prerequisite: A college level programming course. Intended for all engineering, computer science, and science majors. Covers virtual instrumentation including use of IEEE, GPIB, RS232 interfaces, and data acquisition boards. Interface a computer to various instruments for data acquisition and instrument control using a state-of-the-art software platform, such as, National Instrument's LABVIEW. Emphasis is on the practical aspects of interfacing a computer to various instruments including timing issues, real-time data acquisitions and instrument control, instrument status, and acquisition speed.

PHYS 590. Graduate Coop Work Exp I. 1 credit, 1 contact hour.

PHYS 591. Graduate Coop Work Exp II. 1 credit, 1 contact hour.

PHYS 607. Topics in Astronomy and Cosmology. 3 credits, 3 contact hours.
Prerequisites: college-level physics and mathematics. A survey of recent progress in astronomy, the physical principles involved, and the impact these new discoveries have on our understanding of the universe. Includes results from recent and ongoing planetary probes of our solar system, discovery of planetary systems around other stars, the evolution of stars, exotic objects such as neutron stars and black holes, the formation of galaxies, and current understanding of the birth and final fate of the universe. Observing sessions familiarize students with the sun, moon, and night sky.

PHYS 611. Adv Classical Mechanics. 3 credits, 3 contact hours.

PHYS 621. Classical Electrodynamic. 3 credits, 3 contact hours.

PHYS 641. Statistical Mechanics. 3 credits, 3 contact hours.

PHYS 652. Fund of Optical Imaging. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) This is designed as a principal course of introducing optical engineering to master students in applied optics. The goal is to help students acquire the practical technical knowledge on optical systems and their design. The general approach throughout the course is to emphasize the application of basic optical principles to practice. Topics include general principles of geometric and physical optics, elemental geometric optics under paraxial ray approximation, aberrations, prisms and mirrors, the eye, stops and apertures, optical materials and interference coating, radiometry and photometry, basic optical devices, optical computation, image evaluation and optical system design, particularly computer aided designs.

PHYS 661. Solid-State Physics. 3 credits, 3 contact hours.
Properties of solid state materials are explained based on principles of physics. Electronic, magnetic, thermal, optical, and lattice properties of materials are studied. Various experimental and theoretical approaches are introduced.

PHYS 681. Solar Phys & Instrumentn. 3 credits, 3 contact hours.

PHYS 682. Introduction To Mems. 3 credits, 3 contact hours.

PHYS 687. Physics of Materials. 3 credits, 3 contact hours.
Prerequisite: PHYS 441 or equivalent (see undergraduate catalog for description). Fundamentals of quantum mechanics; energy bands in crystals; electrical conduction in metals and alloys, semiconductors; optical properties of materials; quantum mechanical treatment of optical properties; magnetic properties of materials; thermal properties, heat capacity, and thermal expansion in solids.

PHYS 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
More emphasis on analytical methods and statistics. Course will be required for Ph.D. students in Materials Science.

PHYS 690. Directed Study Appl Phys. 3 credits, 3 contact hours.

PHYS 698. ST:. 3 credits, 3 contact hours.

PHYS 700. Master'S Project. 3 credits, 3 contact hours.
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics who do not take Phys 701 Master's Thesis. An extensive paper involving experimental or theoretical investigation of a topic in microelectronics or other applied physics area is required. Cooperative projects with industry or government agencies may be acceptable. The project is carried out under the supervision of a designated physics graduate faculty member.

PHYS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. A written report must be submitted to the project advisor. The student cannot register in PHYS 700B more than once and the incomplete (I) grade is not allowed.

PHYS 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics. Experimental or theoretical investigation of a topic in microelectronics or other applied physics area. Cooperative projects with industry or government agencies may be acceptable. The thesis is written under the supervision of a designated physics graduate faculty member. The completed written thesis should be of sufficient merit to warrant publication in a scientific or technical journal. The student must register for a minimum of 3 credits per semester. Degree credit is limited to 6 credits indicated for the thesis.

PHYS 701B. Master'S Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in PHYS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHYS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (PHYS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHYS 721. Classical Electrodynamics II. 3 credits, 3 contact hours.
Prerequisite: PHYS 621 or equivalent; basic knowledge of tensor analysis. Simple radiating systems, scattering and diffraction; special theory of relativity; dynamics of relativistic particles and electromagnetic fields; collisions between charged particles, energy loss, and scattering; radiation from accelerated charge, synchrotron radiation, and bremsstrahlung.

PHYS 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

PHYS 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for PHYS 726 if they have taken PHYS 725 in a prior semester.

PHYS 728. Radio Astronomy. 3 credits, 3 contact hours.
Prerequisites: PHYS 621and PHYS 641 or the equivalent, or approval of the instructor. An introduction to radio emission processes, radiative transfer, radio diagnostics, and radio instrumentation. Topics include radio flux measurements with single antenna, radio imaging with interferometer arrays (Fourier Transform imaging), and image reconstruction techniques (CLEAN, MEM). Application is to astronomical objects with special emphasis on the Sun.

PHYS 731. Quantum Mechanics II. 3 credits, 3 contact hours.
Prerequisite: PHYS 631 or equivalent. Review of quantum mechanics and theory of special relativity; second quantization; relativistic one-particle problem; Klein-Gordon equation and Dirac equation; canonical field theory; relativistic scattering theory; introduction to quantum electrodynamics and quantum field theory; Feynman diagrams and applications.

PHYS 741. Basic Plasma Phys w Space, Lab. 3 credits, 3 contact hours.
Prerequisites: PHYS 611, PHYS 621, other equivalent, or approval of the instructor. The course will introduce students to basic concepts of plasma physics and its applications to laboratory experiments and space research. The course will cover the following topics: particle motions in magnetic field, adiabatic invariants, magnetic traps, radiation belts, electromagnetic waves in plasma, electrostatic oscillations, waves in magnetized plasma, collisional processes in plasma, kinetic effects on plasma waves, Landau damping, wave instabilities, plasma as fluid, magnetohydrodynamics, magnetic configurations of laboratory and space plasma, MHD instabilities, reconnection, helicity, dynamo theories, the origin of cosmic magnetic fields, stochastic processes, Fermi process, particle acceleration, and cosmic rays.

PHYS 747. Intro to Helioseismology. 3 credits, 3 contact hours.
Prerequisites: Phys 611, Phys 621 or other equivalent The course will introduce the physical principles and methods to study wave oscillations, and the interior structure of the Sun. The course covers processes of acoustic and gravity wave excitation and propagation, interaction with turbulence and magnetic fields, oscillation spectrum, sunquakes, inferences of the structure and composition, the differential rotation, large-scale flows and meridional circulation. It includes the theory of normal modes, inversion techniques, wave dispersion analysis, acoustic tomography and holography, applications to the solar dynamo and magnetic activity.

PHYS 751. Applied Optics. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) The course will introduce students to basic concepts of applied optics, light propagation and light and matter interactions. The course will cover the following topics: light propagation through mirrors and lenses, matrix optics, basic concepts of wave optics, reflection, refraction and transmission, equations governing wave propagation, Gaussian beams, Maxwell's equations, absorption, dispersion, light polarization states, temporal and spatial coherences.

PHYS 753. Light Sources & Photodetectors. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) and PHYS 631 (Quantum Mechanics I) This is a survey course on theory and practical aspects of light sources and photodetectors. The specific light sources covered will be: black body, discharge tubes, X-ray, light.

PHYS 774. Fundamentals of Spectroscopy. 3 credits, 3 contact hours.
The major objectives of this course are to integrate theory and practice and to bring together different branches of Academic Studies and Industrial Research through the presentation of critical aspects of modern Spectroscopy. The course will provide a valuable theoretical introduction and an overview of modern topics in spectroscopy, which are of current interest and importance in Semiconductor Industry and Biomedicine. A wide range of techniques is considered, including optical Near field spectroscopy, X-ray, Raman, Neutron scattering, and FT-IR spectroscopy.

PHYS 780. Curr Topics Applied Phys. 3 credits, 3 contact hours.

PHYS 787. New Concepts of Semiconductor. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 and ECE 657. This is an advanced course on semiconductor physics targeted at describing polycrystalline materials, e.g. cadmium telluride or copper indium diselenide, that are currently used in thin-gilm photovoltiac panels. An overview of classical semiconductor and solar cell theory is followed by topics such as non-shallow dopants, multi-level defects, defect transition energy level, and metastability. These concepts are applied to examine minority carrier lifetime and carrier collection in devices, and to extend the theories of admittance and deep level transient spectroscopy.

PHYS 789. Physics of Advanced Semiconductor Device Processing. 3 credits, 3 contact hours.
Prerequisites: NJIT: EE 657, R755 687; or equivalent. Intended for doctoral students in applied physics, electrical engineering, and materials science. (Rutgers = R755 789)Silicon and GaAS technologies: crystal growth methods, epitaxy, oxidation, lithography, dry and wet etching techniques, polysilicon, diffusion, ion implantation, metallization (including silicidation), process integration, analytical characterization techniques, assembly and packaging, and yield and reliability.

PHYS 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Prerequisites: passing grade on departmental qualifying examination and approval of doctoral candidacy. Corequisite: PHYS 791. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester. Registration for additional credits, up to 12 per semester, is permitted with the approval of the department graduate advisor. Experimental or theoretical investigation of a topic in applied physics, including microelectronics, materials science, and laser physics. Cooperative projects with industry or government agencies may be acceptable. Research and writing are carried out under the supervision of a designated graduate faculty member. The completed written dissertation should be a substantial contribution to the knowledge of the topic under research, and should be of sufficient merit to warrant publication in a leading scientific or technical journal.

PHYS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: PHYS 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. For PhD students who have successfully defended their dissertation proposal. The student must register in PHYS 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

PHYS 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: PHYS 791. Since the PHYS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

PHYS 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: PHYS 791. Since the PHYS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in applied physics. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

PHYS 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

PHYS 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

PHYS 790F. Doct Dissertation & Res. 15 credits, 3 contact hours.

PHYS 790G. Doct Dissertation & Res. 18 credits, 3 contact hours.

PHYS 791. Doctoral Seminar. 0 credits, 0 contact hours.

PHYS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: PHYS 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in applied physics. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

PTC 601. Advanced Professional and Technical Communication. 3 credits, 3 contact hours.
Provides the foundation and direction for all Professional and Technical Communication coursework. This course introduces students to the profession and the academic discipline of technical/professional communication. Modules include usability analysis; visual information; ethics; global diversity, global communication; report writing; information literacy; communicating with new technologies; and technical writing style. Students begin development of the MSPTC ePortfolio.

PTC 603. Identity, Technology, and Communication. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601. Examines the complex ways in which technology constructs and is constructed by society, with emphasis on interrelationships between technology and communication. Discussions focus on how technological change is expressed in social and political movements, literature, art, architecture, and philosophy and how they, in turn, influence the future direction of technology. Design and updating of the MSPTC ePortfolio will be required in this seminar.

PTC 604. Communication Theory and Research. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601Reviews the major theories of communication and provides strategies for research in the field of Professional and Technical Communication. The course focuses on these research methods: problem statement and hypothesis formulation derived from theory; research design and data generation; existing information sources and their acquisition; and analytic techniques. Students develop analytic methods necessary to create a well-considered thesis proposal. Design and updating of the MSPTC ePortfolio will be required in this seminar.

PTC 605. Elements of Visual Design. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601. Provides an understanding of and competency in the visual presentation of information. Course integrates theories of design, techniques of composition, and technologies of electronic and print publishing. Modules include both design principles and hands-on practice in visual literacy, layout and design, and graphic tools. Design and updating of the MSPTC ePortfolio will be required in this seminar.

PTC 606. Advanced Information Design. 3 credits, 3 contact hours.
Develops online visual communication strategies and community building. The course will cover the design and creation of multimedia objects, usability heuristics, navigation theory, contemporary design practices and online community building. Students will be required to create media-rich multidimensional online projects that encourage and facilitate interaction and team-building in the online environment. Design and updating of the MSPTC ePortfolio will be required for this seminar.

PTC 610. Research Methods for Information Design. 3 credits, 3 contact hours.
Introduces user research methods such as contextual inquiry, ethnographic field studies, card sorting, affinity diagramming, and usability testing that provide the foundation for user- centered interaction design.

PTC 612. Theory and Practice of Text Encoding. 3 credits, 3 contact hours.
Students will learn to identify considerations and methods for efficient text encoding. Topics covered will include text encoding tools, markup languages, document analysis, and workflow design for text delivery. After taking this class, students should be able to analyze processes and technologyies that support the collection, management, and publishing of content in a variety of forms and media.

PTC 620. Proposal Writing. 3 credits, 3 contact hours.
Provides an understanding of and practice in proposal writing for corporations, foundations, and government agencies. Students build skills to create a range of persuasive documents including proposals for research grants, responses to requests for proposal, and government proposals.

PTC 622. Working in Teams: Collaborative and Interpersonal Communications. 3 credits, 3 contact hours.
Introduces interpersonal and collaborative communication topics relating to face-to-face and virtual teams. Covers communication and documentation functions in agile project environments. Examines mobile workplace communication strategies.

PTC 624. Professional and Technical Editing. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601 . Presents the theory and practice of editing professional and technical writing. Topics include correctness and conciseness, hard copy and on-line editing, editing graphics, document management, editor-author relationships, and ethical considerations in editing. Students edit writing samples from a variety of technical fields.

PTC 626. Communication Media Design Studio. 3 credits, 3 contact hours.
This course integrates language and media in a studio approach to multimodal communication projects. Students work with instructor to design individual projects using current media applications.

PTC 628. Analyzing Social Networks. 3 credits, 3 contact hours.
Prerequisite: PTC 601 for MSPTC students; approval of instructor for non-MSPTC students. This course will provide students with an overview of social networks by introducing them to the unique terminology of social networks (centrality, boundary spanners, directional ties, etc.) Positive and negative characteristics of social networks will be discussed, followed by visualizations and analyses of those characteristics. Students will read selected journal articles explaining how social networks relate to communication and the flow of information within organizations. The culmination of the course will be a project in which students will create and analyze their own social network, most likely drawing their data from the popular social media site Facebook and using ORA, a freeware social network analysis application created by Carnegie Mellon University.

PTC 629. Theory and Practice of Social Media. 3 credits, 3 contact hours.
Introduces social media strategies for reading and writing in today's multi-cultural, screen-oriented, networked culture. Students study relationship between mediated communication and human community and gain hands-on experience with chatting, blogging, tagging, wiki writing, tweeting and social media presentation. Students strategize, plan, design and produce social media projects of their own.

PTC 631. Communication and Environmental Problem Solving. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601. Develops critical thinking on ecological issues for problem solving by integrating technical information, human values, and communication with environmental change. Students combine theory, research and models, case studies, visual thinking, and scientific inquiry for application in individual decision-making course project.

PTC 632. Content Management and Information Architecture. 3 credits, 3 contact hours.
Prerequisite or Corequisite: PTC 601. Today's complex systems often produce complex information needs that require new technical communication methods and tools. This course will focus on the use of Information Architecture methodologies (such as, DITA or DocBook) to develop a structure for presenting technical information and on Content Management tools for creating a single source repository for this information. Students will also use theory and practical applications to design and develop a structured online Help module.

PTC 640. Health Communications. 3 credits, 3 contact hours.
This course will focus on the use of communication strategies to inform and influence individual and community decisions regarding health. The course will cover: the multidimensional nature of health communication, research in health communication, behavioral theories in health communication, rhetorical theories in health communication, legal and ethical concerns in health communication, the communication of risk and uncertainty, and the design of health campaigns. Students will be required to (a) research and prepare a health communication strategy for use in a specific context and (b) to design an accompanying print or hypertext document to be used in that context.

PTC 642. Corporate Media and Communication. 3 credits, 3 contact hours.
Introduces the dymanics of communication within complex organizations. Develops communication skills for contemporary global corporate and business markets. Focuses on the efforts of businesses and organizations to communicate and persuade in target audiences. Covers translation issues in developing corporate media.

PTC 644. Communication in Technology Transfer and Innovation. 3 credits, 0 contact hours.
Examine roles of communication in innovation development and technolgy transfer. Students review models of communication in technology transfer in global contexts. Issues such as audience analysis, user experience, participatory design, and knowledge transfer will be investigated.

PTC 650. eLearning Design for Mobile. 3 credits, 3 contact hours.
Designing eLearning for mobile platforms is a critical skill for today's technical communicator. Specific skills and tools are required to ensure a successful implementation. Based on proven user centered design concepts, this course provides the student with the skills necessary to create effective mobile training programs.

PTC 672. Design Instruction Assess Meth. 3 credits, 3 contact hours.
Prerequisite: Students must have a graduate standing and should be enrolled in MSPTC program or the Instructional Design and Educational Assessment certificate. Student must meet these requirements, approval of instructor is required. Examines planning and implementation of instruction to facilitate learning and analysis of methods of data gathering on learner progress and mastery, lessons and learning objects so appropriate instructional strategies with associated methods of formative and summative assessments that can yield data for learner assessment and course evaluation can be selected or develop to suit the instructional style, learner needs, and instructional situations.

PTC 681. Tech in Class & Learning Envir. 3 credits, 3 contact hours.
Prerequisite: Students must have a graduate standing and should be enrolled in MSPTC program or the Instructional Design and Educational Assessment certificate. Student must meet these requirements, approval of instructor is required. This course examines the various types of technology necessary to develop, use, and process the results of assessments as well as facilitate and augment instructional design. This course examines the integration of present and likely future technology into instruction to foster community, collaboration, conceptual development, and exceptional academic performance as well as a more effective and well-understood assessment system.

PTC 691. ePortfolio Capstone Seminar. 0 credits, 0 contact hours.
This course is taken in the student's final semester before graduation. Students complete final revisions of the ePortfolio of work completed in MSPTC seminars (may also include professional and service projects). Student ePortfolios must successfully demonstrate MSPTC core competencies and be presented in an oral presentaiton for faculty and other students.

PTC 698. Selected Topics in Professional and Technical Communication. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601 This is a Special Topics course (does not require CGE approval). It was presented to CGE in an effort to attract more students. Students will learn approaches to understanding and producing the forms of writing central to academic research. They will review literature, peer-review the work of others, prepare conference material, and produce a submission-quality journal or conference paper in their field of study. The current plan is to run the course every Spring.

PTC 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisites: Approval of graduate advisor, and completion of core courses. Requires demonstration of student's ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. Based on experiential research (internship, co-op, work experience) student submits a proposal, develops a project (e.g., guidebook, manual, online documentation, website, video, podcast) and completes a paper describing the theory and methodology supporting the project application. Submission of the MSPTC ePortfolio demonstrating proficiency is required for graduation.

PTC 700B. Master'S Project. 3 credits, 3 contact hours.
Prerequisites: Approval of graduate advisor, and completion of core courses. Requires demonstration of student's ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. Based on experiential research (internship, co-op, work experience) student submits a proposal, develops a project (e.g., guidebook, manual, online documentation, website, video, podcast) and completes a paper describing the theory and methodology supporting the project application. Submission of the MSPTC ePortfolio demonstrating proficiency is required for graduation.

PTC 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until thesis in completed. Total will be limited to 6 credits.

PTC 701B. Master'S Thesis. 3 credits, 3 contact hours.
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until thesis in completed. Total will be limited to 6 credits.

PTC 701C. Master'S Thesis. 6 credits, 3 contact hours.
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until thesis in completed. Total will be limited to 6 credits.

PTC 725. Independent Study in Professional and Technical Communication. 3 credits, 3 contact hours.
Prerequisite: approval of graduate advisor and supervising faculty.Allows development of areas of specialization for Master's Project or for areas of study in communication in which one or more students may be interested but which are not of sufficiently broad interest to warrant a regular course offering.

PTC 726. Independent Study II. 3 credits, 3 contact hours.

R215 510. Conservation Ecology. 1-12 credits, 1-12 contact hours.

R215 520. Landscape Ecology. 3 credits, 3 contact hours.

R215 565. Community Dynamics. 4 credits, 4 contact hours.

R215 575. Quant Ecol & Evol. 3 credits, 3 contact hours.

R215 590. Population Ecology. 4 credits, 4 contact hours.

R215 597. Concpt & Meth Evolution. 4 credits, 4 contact hours.

R215 599. Special Topics. 3 credits, 3 contact hours.

R215 604. ST:. 3-12 credits, 3-12 contact hours.

R460 606. Envir. Geophysics. 3 credits, 0 contact hours.

Biological Sciences

Master of Science in Biology

Master of Science Graduate Program in Biology Course of Study and Program Requirements

Advisement

In the first year of study, students are advised on all academic matters by the MS Program Coordinator. During the first year of full-time study (or part-time equivalent), students complete sufficient course work to fulfill most core curricular requirements and to develop a potential research project (library or laboratory) that will serve as the basis of the capstone Thesis requirement. By the start of the second year, students must choose a faculty member to serve as advisor during their laboratory or bibliographic thesis research project.

Other Source of Information Regarding the Program's Regulations

The Rutgers-Newark Graduate School Catalog (http://catalogs.rutgers.edu/generated/nwk-grad_current/pg127.html) and the NJIT Graduate Catalog http://catalog.njit.edu/graduate/ (http://catalog.njit.edu/archive/2019-2020/graduate/) should be consulted for University regulations. The new department regulations outlined above for the Masters program in Biology apply to all students who enter the Program as of September 2010.

Doctor of Philosophy in Biology

Program Procedures and Requirements

I. Graduate Standards Committee

The Graduate Standard Committee is responsible for monitoring and advising all graduate students through completion of the Thesis Prospectus stage of the program. The Committee meets with students each semester to evaluate coursework and research progress in an effort to provide advisement on course selections, first-semester mentoring, laboratory rotations, and potential thesis advisors. Records of Standards Committee meeting are kept on file via the Standards Committee Report form. Whenever necessary, the Committee will discuss student progress with faculty mentors and advisors to ensure proper and successful progress within the program. The ultimate charge of the Committee is to assist and guide the student toward successful completion of the Qualifying Exam and Thesis Prospectus.

NJIT Faculty

B

Bucher, Dirk M., Associate Professor

Bunker, Daniel E., Assistant Professor

F

Flammang-Lockyer, Brooke E., University Lecturer

Fortune, Eric S., Associate Professor

G

Garnier, Simon J., Assistant Professor

Golowasch, Jorge P., Professor

H

Haspel, Gal, Assistant Professor

N

Nadim, Farzan, Professor

R

Russell, Gareth J., Associate Professor

S

Soares, Daphne F., Assistant Professor

Stanko, Maria L., University Lecturer

T

Trimby, Christopher M., University Lecturer

W

Wisner, Ellen M., University Lecturer

Y

Yarotsky, John J., University Lecturer

- Biology - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/biology/ms/)
- Biology - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/biology/phd/)

Biological Sciences Courses

BIOL 590. Grad Coop Work Experience I. 1 credit, 1 contact hour.

BIOL 591. Graduate Coop Work Exper II. 1 credit, 1 contact hour.

BIOL 593. Graduate Co-Op Work Exp IV. 0 credits, 0 contact hours.

BIOL 601. Computational Biology I. 3 credits, 3 contact hours.
This course will describe mathematical and simulation techniques used in modeling a variety of biological systems. Students will learn stability analysis, phase space analysis, basic bifurication theory and numerical simulation techniques with examples from neuroscience, cell and molecular biology as well as ecology and evolution. Students enrolling in this course are expected to have basic knowledge of calculus, linear algebra and some programming abilities.

BIOL 605. Prin of Bioscience Processing. 3 credits, 3 contact hours.
This course covers the main concepts of cell physiology, molecular biology, and cell biology. The fundamental aspects of biochemistry that relate directly to pharmaceutical developments are discussed and include basic organic chemistry, blood and buffers, protein based enzymes, complex carbohydrates, nucleic acids, and fats. Those topics will then be integrated into a thorough understanding of Bioprocessing in pharmaceutical industries. This course is for Professional Science Master's Biotechnology students with limited knowledge of Biology.

BIOL 606. App Bioproc & Immun Based Ther. 3 credits, 3 contact hours.
Prerequisite: BIOL 605 or permission of the instructor. This course provides foundational knowledge about immunology and immunological applications relevant to bioprocessing science including immunoglobulin genetics, leukocyte activation and migration, transplant immunology, and immunotherapy and vaccines.

BIOL 610. Comparative Vertebrate Anatomy. 3 credits, 3 contact hours.
This course introduces students to the groups of vertebrates and explores the anatomical evolution of vertebrates within the context of the functional interrelationships of organs and the changing environments to which vertebrates have adapted. An ideal entry point into the ways living creatures interact with their immediate physical world, we examine how the forms and activities of animals reflect the materials available to nature and consider rules for structural design under environmental forces.

BIOL 612. Comparative Animal Physiology. 3 credits, 3 contact hours.
This course will explore how animals, from invertebrates to vertebrates, function from the cellular to the organism level. The study of the structure and function of the various organs provides insight into how animals survive extreme environments and how they respond to changes in their environment. The comparative approach shows that the underlying physiological principles that govern life are common to all animals and yet animals have evolved unique and sometimes startling physiological solutions to problems posed by their particular environments.

BIOL 622. Evolution. 3 credits, 3 contact hours.
This course will provide a comprehensive overview of research in the field of evolutionary biology. Topics will include: the development of evolutionary theory, the history of the evolution of life on Earth, the genetic bases of variation and heredity, natural selection, evolution and development, and speciation. The format will be brief lectures to review topics covered in text, followed by class discussions of relevant primary literature. Students will write two papers on the topic of their choice and will be required to lead a minimum of one class discussion.

BIOL 628. Cell Biology of Disease: Cells Gone Bad. 3 credits, 3 contact hours.
This course will briefly review normal physiological function of humans and will then extensively explore the basis of many human diseases at cellular lever. The goal is to understand how alterations in normal cell functions affect human physiology by reviewing current research in the field of cell biology.

BIOL 630. Critical Thinking for the Life Sciences. 3 credits, 3 contact hours.
Researchers in the biological sciences must understand and be able to effectively apply the scientific method, and they must also be able to clearly communicate their ideas and results. This course will involve heavy student participation and discuss the scientific method, analyze and discuss data gathering and organizing, and will analyze existing grant proposals with the goal of enabling graduate students to write a clear and convincing grant proposal.

BIOL 631. Proposal Prep for Extnl Fundin. 3 credits, 3 contact hours.
Prerequisite: BIOL 630. This course is intended for doctoral students in their first or second year who intend to apply for external funding for their research. The course is hands-on and students are required to identify sources of funding and to write and submit a grant proposal. Topics covered include developing research questions and hypotheses, organization of specific aims, components of the proposal, including significance, innovation, expected outcomes, potential pitfalls and broader impact. The course also emphasizes practices of good grantsmanship and provides an overview of how proposals are reviewed at NSF and NIH.

BIOL 635. Intro to Comp Neuroscience. 3 credits, 3 contact hours.
Prerequisite: Permission by instructor. Introduction to the modeling, computational and analysis techniques for single neurons and small neuronal networks. The course work is designed so that students can develop an independent modeling/computational project by the end of the semester. The required knowledge of neurobiology, electric circuits and numerical tools for the solution of differential equations will be introduced as needed.

BIOL 636. Advanced Comp Neuroscience. 3 credits, 3 contact hours.
Prerequisites: BIOL 635 or permission by the instructor. Modeling and computational analysis of biological neuronal networks. The course consists of lectures, scientific paper presentations and computational work. Students are expected to develop an independent modeling/computational project by the end of the semester.

BIOL 638. Computational Ecology. 3 credits, 3 contact hours.
An overview of computational approaches to the study of mathematical models in ecology. Topics include one-, two-, and multi-species models, life history analysis, spatial dynamics, epidemiology. The course is taught as a hands-on computer lab in which students explore models, perform simulations and solve problems.

BIOL 640. Cellular Neurophysiology. 3 credits, 3 contact hours.
Prerequisites: Graduate student status or permission of the instructor. This course will examine the nervous system from a functional perspective. The goal is to understand how ion channels and other components of nerve cells give rise to electrical excitability and synaptic function, and how those properties are then used for coding information and higher order function in the nervous system.

BIOL 641. Systems Neuroscience. 3 credits, 3 contact hours.
This course will examine neurophysical phenomena from a systems perspective. The course will review basic concepts of cellular neuroscience, such as excitability, impulse conduction, and integration of activity at the cellular, before focusing on network level physiology of the nervous system and its role in the generation of behavior. The goal is to provide students with the basic knowledge to understand neurobiological processes at all levels of complexity.

BIOL 645. Biological Imaging Techniques. 3 credits, 3 contact hours.
Prerequisites: Graduate student status or permission of the instructor. This combined lecture and lab course will introduce the students to a variety of approaches to examine biological structures at different microscopic scales: conventional light microscopy, fluorescent microscopy, modern high resolution light microscopy, and electron microscopy. In addition, the course will cover optical approaches to study the dynamics of cellular function, including calcium and voltage imaging, and molecular interactions.

BIOL 660. College Teaching. 3 credits, 3 contact hours.
College Teaching helps students in STEM fields who teach or plan to teach in colleges or universities develop important professional knowledge, skills, values, and dispositions that can enable them to help undergraduate and graduate students develop societally and personally significant abilities. The course emphasizes research-based methods demonstrated to be effective for enhancing learning in diverse people.

BIOL 672. Computational Systems Biology. 3 credits, 3 contact hours.
Prerequisite: Permission by the instructor. Introduction to the mathematical and computational modeling of biological systems with a focus on chemical, biochemical, metabolic and genetic networks. The course work is designed so that students can develop an independent modeling/computational project by the end of the semester. The required knowledge of biology and numerical tools for the solution of differential equations will be introduced as needed.

BIOL 698. Selected topics in Biology. 3 credits, 3 contact hours.
Survey of recent research topics in Biology at the Master's level.

BIOL 699. Selected Topics in Biology. 3 credits, 3 contact hours.
Survey of recent research topics in Biology at the Masters level.

BIOL 700. Master's Project. 0 credits, 0 contact hours.

BIOL 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology. A written report must be submitted to the project advisor. The student cannot register in BIOL 700B more than once and the incomplete (I) grade is not allowed.

BIOL 701. Master's Thesis. 0 credits, 0 contact hours.

BIOL 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in BIOL 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

BIOL 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (BIOL 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

BIOL 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

BIOL 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for BIOL 726 if they have taken BIOL 725 in a prior semester.

BIOL 788. Selected Topics in Biology. 3 credits, 3 contact hours.
Survey of recent research topics in Biology at the doctoral level.

BIOL 790. Doct Dissertation & Resrch. 0 credits, 0 contact hours.

BIOL 790A. Doct Dissertation & Resrch. 1 credit, 1 contact hour.
Co-requisite: BIOL 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in biology. For PhD students who have successfully defended their dissertation proposal. The student must register in BIOL 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

BIOL 790B. Doct Dissertation & Resrch. 3 credits, 3 contact hours.
Co-requisite: BIOL 791. Since the BIOL 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in biology. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

BIOL 790C. Doctoral Dissertn & Resrch. 6 credits, 6 contact hours.
Co-requisite: BIOL 791. Since the BIOL 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in biology. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

BIOL 790D. Doct Dissertation & Resrch. 9 credits, 0 contact hours.

BIOL 790E. Doctoral Dissertation. 12 credits, 12 contact hours.

BIOL 791. Biology Seminar. 0 credits, 0 contact hours.
This seminar includes student and faculty presentations on current papers, student presentations related to their research and occasional outside speakers. It will acquaint students with possible topics for dissertation search, and provide an opportunity to present and receive feedback on current work.

BIOL 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: BIOL 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in biology. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

BIOL 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

BIOL 792D. Pre-Doctoral Research. 12 credits, 12 contact hours.

BIOL 794. Computational Biology Colloquium. 1 credit, 1 contact hour.
Restriction: graduate standing. Students and outside speakers present and discuss current research activities in computational biology and related scientific areas.

Rutgers-Newark Courses

R120 503. Plant Morphology. 3 credits, 3 contact hours.

R120 504. Plant Physiology. 3 credits, 3 contact hours.

R120 505. Bio Stat And Compt Meth. 3 credits, 3 contact hours.

R120 509. Adv Problems In Biology. 3-5 credits, 3-5 contact hours.

R120 510. Adv Prob In Biol. 3 credits, 3 contact hours.

R120 512. Cell Biology: Methods & Appl. 3 credits, 0 contact hours.

R120 515. Molecular Bio Of Eukaryotes. 3 credits, 3 contact hours.

R120 516. Microbial Ecology. 3 credits, 3 contact hours.

R120 517. Develomental Neurobiology. 3 credits, 3 contact hours.

R120 518. Neuroimmunology. 3 credits, 3 contact hours.

R120 519. Microbial Metal. 3 credits, 0 contact hours.

R120 520. Analyt & Comp Neurosci. 3 credits, 3 contact hours.

R120 522. Resource Sustainability. 3 credits, 3 contact hours.

R120 523. Scale Of Biodiversity. 3 credits, 3 contact hours.

R120 524. Cell Molec Dev. 3 credits, 3 contact hours.

R120 526. Topics in Cell Biology. 3 credits, 0 contact hours.

R120 530. Cell Surface Recept. 3 credits, 3 contact hours.

R120 532. Evolution. 3 credits, 3 contact hours.

R120 534. Biological Invasion. 3 credits, 3 contact hours.

R120 536. Mulitvariate Biostatistics. 3 credits, 3 contact hours.

R120 538. Topics In Molecular Genetics. 3 credits, 3 contact hours.

R120 539. Adv Human Physio I. 3 credits, 0 contact hours.

R120 540. Adv Human Phsiology & Patho II. 3 credits, 3 contact hours.

R120 543. Envr Microbiology. 3 credits, 3 contact hours.

R120 545. Plant Molecular Bio. 3 credits, 3 contact hours.

R120 547. Pathophysiology. 3 credits, 3 contact hours.

R120 548. Biology Of Cancer. 3 credits, 3 contact hours.

R120 551. Biology Of Pollution. 3 credits, 3 contact hours.

R120 552. Paleobotany. 3 credits, 3 contact hours.

R120 560. College Teaching. 3 credits, 3 contact hours.

R120 563. Topics in Modern Plant Biology. 3 credits, 3 contact hours.

R120 568. Neuroendocrinology. 3 credits, 0 contact hours.

R120 571. Biochemistry I. 3 credits, 3 contact hours.

R120 572. Concepts in Pharm Drug Dev. 3 credits, 3 contact hours.

R120 573. Pharmacology. 3 credits, 3 contact hours.

R120 580. Topic Marine Ecology. 3 credits, 3 contact hours.

R120 587. Systems Ecology. 3 credits, 0 contact hours.

R120 588. Topics Adv Ecology. 3 credits, 0 contact hours.

R120 590. Intro to Env Biophys. 3 credits, 3 contact hours.

R120 593. Physiological Ecol. 3 credits, 0 contact hours.

R120 594. Systematics. 3 credits, 3 contact hours.

R120 601. Human Molecular Genetics. 3 credits, 3 contact hours.

R120 604. Microbio: Prin & Appl. 3 credits, 3 contact hours.

R120 616. Topics In Biology. 3 credits, 3 contact hours.

R120 624. Cell Biol:Signal Transduction. 3 credits, 3 contact hours.

R120 640. Topics In Immunology. 3 credits, 3 contact hours.

R120 651. Biology Colloquium. 1 credit, 1 contact hour.

BIOTECHNOLOGY

Bioprocessing and biotechnology are a specialized forms of chemical and biological science and engineering that encompasses agriculture, food, pharmaceuticals, chemicals, paper, and other materials. It also covers large scale industry production for yield optimization and end product quality. From the NJIT Department of Chemistry and Environmental Science, the Graduate Certificate in Biotechnology will cover these topics in depth.

Who would be suited to take this program?

Typical students in this program could be from the pharmaceutical/biopharmaceutical world or strictly come from a biological or chemical science background, but could also come from an environmental science or engineering background as well. Such occupations may be pharmaceutical biologics scientists, food/drug development specialists, agricultural scientists, biomedical scientists, bacteriologists, and others.

What are the Required Courses?

Code	Title	Credits
Core Courses		
Take these three (3) courses:		9
BIOL 605 (http://catalog.njit.edu/archive/2019-2020/search/?P=BIOL 605)	Principles in Bioscience Processing	
BIOL 606 (http://catalog.njit.edu/archive/2019-2020/search/?P=BIOL 606)	Applied Bioprocessing and Immunological Based Therapies	
CHEM 673 (http://catalog.njit.edu/archive/2019-2020/search/?P=CHEM 673)	Biochemistry	
Electives - Choose one (1) course:		3
EVSC 616 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 616)	Toxicology	
CHEM 714 (http://catalog.njit.edu/archive/2019-2020/search/?P=CHEM 714)	Pharmaceutical Analysis	
CHEM 777 (http://catalog.njit.edu/archive/2019-2020/search/?P=CHEM 777)	Principles of Pharmaceutical Chemistry	

What will I learn?

- ***Principles in Bioscience Processing -*** The main concepts of cell physiology, molecular biology, and cell biology. The fundamental aspects of biochemistry that relate directly to pharmaceutical developments are discussed and include basic organic chemistry, blood and buffers, protein based enzymes, complex carbohydrates, nucleic acids, and fats.
- ***Applied Bioprocessing and Immunological Based Therapies -*** The foundational knowledge of immunology and immunological applications relevant to bioprocessing science including immunoglobulin genetics, leukocyte activation and migration, transplant immunology, and immunotherapy and vaccines.
- ***Biochemistry -*** Fundamentals of biochemistry related to physical organic chemistry for students who have an interest in biomedical engineering, chemistry, chemical engineering, or environmental science.
- ***Toxicology -*** The general principles of toxicology are presented and applied to the assessment of acute, subacute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management.
- ***Pharmaceutical Analysis -*** Instrumental techniques used in the analysis of different pharmaceutical products. Many different types of analysis are carried out in the pharmaceutical industry pertaining to active ingredients, formulations as well as impurities and dgradants. The focus will be on instrumentation such as chromatography, mass spectroscopy, different types of spectroscopy, quality assurance and GMP.
- ***Principles of Pharmaceutical Chemistry -*** Drug design and the molecular mechanisms by which drugs act in the body. Pharmacodynamics, pharmacokinetics, molecular targets used by drugs, the interaction of a drug with a target, and the consequences of this interaction. Strategies used

in discovering and designing new drugs, and surveys the "tools of the trade" involved, e.g., QSAR, combichem and computer aided design. Special topics like chlorinergics, analgesics, opiates, antibacterials, antivirals, and anti-ulcer agents.

Why study Biotechnology at NJIT?

NJIT is uniquely situated among the greatest concentration of biotechnology and pharmaceutical activities in the world, with over 400 private and public biopharmaceutical companies thriving around the NJ Area. Opportunity is right outside our door. The mission of NJIT's professional Biotechnology option in the MS Pharmaceutical Chemistry program is to prepare scientists and engineers for dynamic careers in biopharmaceutical industry. The program will focus on providing integrated coursework and training in current biotechnology industry practices. Our approach, relying on the input of our industrial advisory board, will ensure that our program will keep students up-to-date on the latest biotechnology industry changes and challenges and prepare them to work in this growing and exciting industry. NJIT's professional Biotechnology program will provide a solid grounding in science and engineering, with an industry focus, facilitating the tailoring of coursework to meet individual career goals.

"This program complements NJIT's programs in pharmaceutical chemistry and pharmaceutical engineering and was deliberately developed in partnership with biopharmaceutical companies to address unmet workforce needs," said Kevin Belfield, dean of NJIT's College of Science and Liberal Arts. "We anticipate our graduates will be in high demand in the state's biopharmaceutical industry."

Into what industries might holders of this program find employment?

Bioprocessing and Biopharmaceutical companies, such as Celgene, Amicus Therapeutics, Chromocell, Soligenix, Vicus, Genzyme, Roka Biosciences and PTC Therapeutics.

Prerequisites

Applicants should have a bachelor's degree in the chemical or biological sciences or engineering preferred.

Related Degree Programs

All courses in this program related entirely to the NJIT MS in Pharmaceutical Chemistry (https://chemistry.njit.edu/academics/graduate/pharmchem/)

Faculty Advisor: Kevin Belfield (https://chemistry.njit.edu/faculty/belfield/)

M.S. in Biology

Curriculum-Course and Credit Requirements

The program requires successful completion of a minimum of 30 credits of graduate-level work. These must include at least one 3-credit course in each of four of the following five core areas:

1. cell biology/biochemistry,
2. molecular biology,
3. computational biology,
4. ecology/evolution,
5. plant biology.

A partial list of courses offerings in each of these areas is appended. When nearing completion of, the minimum 30 required credits for the MS, Rutgers students must submit and Application for Admission to Candidacy for the Degree of Master of Science to the Graduate Program Director listing courses complete (totaling 30 credits) and offered toward the degree. NJIT students must complete an application for graduation and submit it to the Graduate Program Director for signature.

Curriculum-Thesis Requirements

Students can fulfill the written thesis requirement either by conducting laboratory or library research. Important to successful completion of the thesis requirement is early identification of a thesis advisor such that proper planning is in place to complete research requirements in a timely and effective manner. The basic requirement and process for these two thesis pathways is laboratory or field research thesis option; or bibliographic thesis option.

Laboratory or Field Research Thesis Option

Students selecting the experimentally-based **research thesis option** must successfully complete a minimum of 24 credits of course work and 6 credits in research (R120 701 Research In Biology, R120 702 Research In Biology for RU-N students, BIOL 700 Master's Project, BIOL 701 Master's Thesis for NJIT students) with a graduate faculty of the department. Under the guidance of this faculty member the student will perform original research. The thesis resulting from this research is expected to be presented as an hypothesis-driven scholarly work, with conclusions clearly derived from the experimental research and published background information. Students will write a scholarly thesis demonstrating the ability to write clearly and scientifically and based on experimental laboratory and/or field project research.

Upon completion of the written thesis, the student will defend the thesis publicly on the topic of their research, followed by a Q&A session with the examination committee. The thesis committee must be approved by the Graduate Program Director and will consist of the primary advisor and at least one other faculty reader who are full members of the Graduate Faculty. If a research plan requires the expertise of a non-graduate faculty advisor the committee will consist of three members-two from the graduate faculty and the advisor. Format and style of the final document must be in accordance with the guidelines set by an available at the office of graduate studies of the respective institutions.

Bibliographic Thesis Option

Students selecting the bibliographic-based **research thesis option** must successfully complete a minimum of 27 credits of coursework and 3 credits of Independent Study (BIOL 725 Independent Study I for NJIT students, R120 844 Research Internship for Rutgers students) with a graduate faculty member of the department. Under the guidance of this faculty member, the student will write a scholarly review of the literature on a scientific topic of interest. The thesis resulting from this research is expected to be a scholarly work, with conclusions clearly derived from the published information referred to by the author. This thesis should demonstrate the ability of the student to write scientifically, bringing together facts interpretations relevant to that topic, in a clear, scholarly manner. Upon completion of the written thesis, the student will defend it publicly, followed by a Q&A session with the examination committee. The thesis committee must be approved by the Graduate Program Director and will consist of the primary advisor and at least one other faculty reader who are full members of the Graduate Faculty. If a research plan requires the expertise of a non-graduate faculty advisor the committee will consist of three members-two from the graduate faculty and the advisor. Format and style of the final document must be in accordance with the guidelines set by and available at the office of the graduate studies of the respective institutions.

Additional Curriculum Options

RU-N students

- After completing 12 graduate credits in the program, a student may solicit the Graduate Program Director to transfer up to 9 relevant graduate credits from another institution toward the 30 credits need for MS.
- No undergraduate credits are allowed for credit towards the MS degre.

NJIT students

- *Credits already taken:* Up to nine (9) credits may be transferred for credit toward the 30 credits need for the MS provided that they were taken at an accredited college or university in the United States or Canada, were not used in fulfillment of a previous degree awarded, earned a final grade of 3.0 or above on a scale whose maximum is 4.0, were earned in graduate level course(s) for which full academic credit was awarded, were in units of at least three (3) credits and were not earned more than seven years ago. Credits earned in quarter system will be converted to equivalent semester credits.
- *Credits Not Yet Taken:* Up to nine (9) credits may be transferred for credit provided that they are taken at an accredited college or university in the United States or Canada, earn a final grade of 3.0 or above on a scale whose maximum is 4.0, are in graduate level course(s) for which full academic credit is awarded, and are in units of at least three (3) credits. Credits earned in quarter systems will be converted to equivalent semester credits. Prior approval required.

Part-Time Students

Part-time students are expected to fulfill exactly the same requirements as full-time students

NEUROSCIENCE

(12 credits)

Offered by the Department of Biology, the Graduate Certificate in Neuroscience is an exciting program with new courses launched in the Fall of 2018. The program bridges many levels of nervous system organization and function, from single nerve cells to behavior and cognition. Students will be introduced to the cell and molecular biology, biophysics, and electrophysiology of nerve cells and synapses. They will learn how these properties give rise to neural circuit and systems function, and how computational and signal processing approaches are used to understand neural coding and information processing in the brain. The fundamental biological and computational principles that govern brain function can then be applied to understand diagnostic and therapeutic approaches and instrumentation, including functional electrical stimulation, optical and functional imaging techniques, and neural prosthetics.

Who would be suited to take this program?

As many aspects of neuroscience are rooted in the basic biology of the nervous system, the program is well suited to students with a biology background. However, neuroscience is inherently multidisciplinary in both fundamental and applied approaches. Therefore, students with backgrounds in computational and mathematical principles of coding and information processing, or engineering applications, are also well matched.

Related MS degree: Biology.

Curriculum

Choose at least two courses from this list:

Code	Title	Credits
BIOL 640	Cellular Neurophysiology	3
BIOL 641	Systems Neuroscience	3
BIOL 645	Biological Imaging Techniques	3
BME 661	Neural Engineering	3
BME 668	Medical Imaging Systems	3
MATH 615	Approaches to Quantitative Analysis in the Life Sciences	3

Choose course(s) from this list after accumulating at least six credits:

Code	Title	Credits
BIOL 635	Intro to Comp Neuroscience	3
BIOL 636	Advanced Comp Neuroscience	3
BIOL 672	Computational Systems Biology	3

Ph.D. in Biology

Course Requirements

General Credit/Course Distribution

Code	Title	Credits
Three Biology Graduate Program Core Courses		9
Two or Three Track Specific Core Courses, dependent on tracj		6-9
Two Semester Long Laboratory Rotations		6
Four or five Elective Courses, dependent on track		12-15
Total Required Research Credits		24
Total Credits		57-63

Ph.D. in Biology (Cell and Molecular Biology)

Code	Title	Credits
Program Core Courses		
R120 560	College Teaching	3
BIOL 630	Critical Thinking for the Life Sciences	3
MATH 615	Approaches to Quantitative Analysis in the Life Sciences [1]	3
Track Core Courses		
R120 524	Cell Molec Dev	3
R120 515	Molecular Bio Of Eukaryotes	3
R160 581	Biochemistry	3
Electives		
Approved electives [2]		12
Two Lab Rotations		
R120 509	Adv Problems In Biology	3
or R120 510	Adv Prob In Biol	
BIOL 725	Independent Study I	3
or BIOL 726	Independent Study II	
Required Research		
Research		24
Total Credits		60

[1] Equivalent course may be substituted if approved.

[2] Elective courses can be any graduate level courses offered by the program, including track core courses from the other tracks. In addition, courses may be taken from a variety of graduate level offerings in different programs at Rutgers University-Newark, NJIT, Rutgers NJMS, Rutgers University-Camden, Rutgers University-New Brunswick, and others. Enrollment in courses offered by graduate programs outside of the Graduate Program in Biology requires permission from the program.

Ph.D. in Biology (Track: Ecology and Evolution)

Code	Title	Credits
Required Courses		
R120 560	College Teaching	3
BIOL 630	Critical Thinking for the Life Sciences	3
MATH 615	Approaches to Quantitative Analysis in the Life Sciences [1]	3
Track Core Courses		
R120 523	Scale Of Biodiversity	3
BIOL 622	Evolution	3
Electives		
Approved electives [2]		15
Two Lab Rotations		
R120 509	Adv Problems In Biology	3
or R120 510	Adv Prob In Biol	
BIOL 725	Independent Study I	3
or BIOL 726	Independent Study II	
Required Research		
Research		24
Total Credits		60

[1] Equivalent course may be substituted if approved.

[2] Elective courses can be any graduate level courses offered by the program, including track core courses from the other tracks. In addition, courses may be taken from a variety of graduate level offerings in different programs at Rutgers University-Newark, NJIT, Rutgers NJMS, Rutgers University-Camden, Rutgers University-New Brunswick, and others. Enrollment in courses offered by graduate programs outside of the Graduate Program in Biology requires permission from the program.

Ph.D. in Biology (Track: Neurobiology)

Code	Title	Credits
Program Core Courses		
R120 560	College Teaching	3
BIOL 630	Critical Thinking for the Life Sciences	3
MATH 615	Approaches to Quantitative Analysis in the Life Sciences [1]	3
Track Core Courses		
BIOL 640	Cellular Neurophysiology	3
BIOL 641	Systems Neuroscience	3
MATH 635	Analytical Computational Neuroscience [2]	3
Electives		
Approved electives [3]		12
Two Lab Rotations		
R120 509	Adv Problems In Biology	3
or R120 510	Adv Prob In Biol	
BIOL 725	Independent Study I	3
or BIOL 726	Independent Study II	
Required Research		
Research		24
Total Credits		60

[1] Equivalent course may be substituted if approved.

[2] Appropriate course may be substituted for students with stronger interests in Cellular and Molecular Neuroscience or Neuroethology and Behavior.

[3] Elective courses can be any graduate level courses offered by the program, including track core courses from the other tracks. In addition, courses may be taken from a variety of graduate level offerings in different programs at Rutgers University-Newark, NJIT, Rutgers NJMS, Rutgers University-Camden, Rutgers University-New Brunswick, and others. Enrollment in courses offered by graduate programs outside of the Graduate Program in Biology requires permission from the program.

Grade Requirements

Students are expected to successfully complete all of the Core and Elective credits taken within the Graduate Program. Course work provides the formal foundation upon which a successful research project and Dissertation Defense is built. To remain in good standing, a GPA of 3.0 or better must be maintained for all courses taken as part of the graduate course of study. Courses cannot be repeated in order to improve on poor performance. Furthermore, while in the program, a student can receive grades of C or C+ in a maximum of two courses, only one of which may be in the Program and Track Core courses.

Biology Colloquium

The Biology Colloquium is held weekly during the semester and consists of research presentations by invited speakers, students, and faculty, as well as professional development/career advice events and organizational meetings. All students, including post-qualifying students, are required to attend while being matriculated in the program.

Mentoring Semester

Every incoming student will be assigned to a “Mentor Lab” for their first semester in the program. During this time, each student is required to actively participate in lab meetings, journal clubs, and other general lab activities. Additionally, the student must participate in some minimal form of research work as determined by agreement with the Faculty Mentor.

Laboratory Rotations

Laboratory rotations provide opportunities for laboratory research and independent study with Graduate Faculty members. Students are required to complete two semester-long rotations. The main objective of the lab rotations is to identify a lab in which to complete dissertation work. Additional anticipated outcomes of the rotations include the development of laboratory and/or computational research skills, development of analytical and critical thinking skills, and appreciation of a specific research field.

Selection of Dissertation Lab

Following completion of the laboratory rotations, students must select a Graduate Faculty member who will serve as their Dissertation Advisor during the research phase of the doctoral program. Once completed, the student will commence developing a project and accumulating preliminary data for the dissertation. The program accommodates joint or interdisciplinary projects supervised by two or more faculty members. One faculty member serves as the Primary Advisor and provides the work space for the student, others can serve as Co-Advisors.

Qualifying Exam

Following the successful completion of all course requirements, rotations, and identification of the Dissertation Advisor, each student must pass a Qualifying Exam to remain in the program. After successful completion of the Qualifying Exam, the student becomes a Ph.D. candidate. The exam is typically held in June of the second year, unless the coursework was completed earlier. The exam will be administered by a Qualifying Exam Committee of three Graduate Faculty members. The overall purpose of the Qualifying Exam is to assess the student’s preparation and ability to plan an original, scholarly scientific investigation. The Qualifying Exam consists of a written research proposal and an oral exam.

Dissertation Committee

Within 9 months of the completion of the Qualifying Exam, the student assembles a Dissertation Committee, under the guidance of the Dissertation Advisor. The Dissertation Committee will be composed of the student’s Dissertation Advisor, one external member from outside the NJIT-Rutgers scholarly community, and three members of the Biology Graduate Faculty. It is the primary advisory group responsible for supervision and guidance of the Student during the research phase of the dissertation. The Dissertation Committee also serves as the examination committee for the Dissertation Defense. The Dissertation Committee regularly meets with the student in 6-12 months intervals to discuss research progress, experimental challenges, and potential changes to the original plan. The ultimate charge of the Dissertation Committee before the Dissertation Defense is to ensure that the student is making appropriate progress towards a timely and successful defense.

Thesis Proposal

Within a year of the Qualifying Exam, the student presents and defends the Thesis Proposal (the dissertation research proposal) to the Dissertation Committee. The written Thesis Proposal should follow the format of NIH or NSF postdoctoral fellowship applications. The Thesis Proposal meeting is an oral exam that will determine the student’s ability to conceive, design, and conduct the proposed research project. It is a required milestone in the program, and approval by the Dissertation Committee should be viewed as a statement that the scope and originality of the proposal is sufficient to earn a Ph.D. degree upon successful completion.

Dissertation Defense

Completing the program and earning a doctoral degree requires a written Thesis, a public Dissertation Defense, and an oral examination by the Dissertation Committee. Approximately six months prior to the planned Dissertation Defense, the Dissertation Committee will evaluate if sufficient progress has been made to warrant final preparation of a thesis and to establish an approximate timetable for the thesis public presentation and private defense. The completed Thesis document must be submitted to all members of the Dissertation Committee at least one month prior to the scheduled Dissertation Defense. The Dissertation Defense must be advertised in advance, with a minimum of 10 days' notice, and open to anyone wishing to attend.

Chemistry and Environmental Science

Chemistry

Master of Science in Chemistry

An undergraduate degree in chemistry or chemical engineering is usually required. Students with baccalaureate degrees in other areas of science and engineering may be considered for admission and required to take an individually designed program that includes undergraduate courses before beginning the graduate program. These courses are not counted toward degree credit.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. General GRE scores must be submitted by those seeking financial support and those whose last prior degree was from outside the United States. Subject GRE is not required. International students must achieve a minimum TOEFL score of 550 (paper and pencil) and 213 (computer based).

Off-Campus Programs: At the National Starch and Chemical Corporation, NJIT offers sufficient courses to fulfill all degree requirements. NJIT faculty teach all courses. For locations, see **Extension Programs** in this catalog. In addition, a distance-based, 12-credit graduate certificate in Applied Chemistry is available as a step toward this degree for employees of the corporation. For further information about extension programs and **Graduate Certificates**, call the Associate Vice President for Continuing and Distance Education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail: cpe@njit.edu.

Doctor of Philosophy in Chemistry

Doctoral candidates are expected to demonstrate creative thinking, self-motivation and a commitment to achieving quality in their research product. Departmental research includes a well-balanced mixture of experimental, computational, and theoretical projects in the areas of analytical, bio-, organic, inorganic, and physical chemistry. Chemistry doctoral students address real problems, have strong interactions with their advisors and are expected to solve pertinent chemical and environmental problems.

Qualified students may be accepted directly into the program with a bachelor's degree or after they have completed a master's degree in chemistry. A GPA in previous work of 3.5 or better is expected, and international students must submit a TOEFL score of at least 550 (214 on the computer based test). General GRE scores are also required for admission. GRE subject scores are not required. Although the program is intended for full-time students, courses many be taken on a part-time basis initially. A minimum of one year in full-time residency required for completion of the dissertation. Teaching assistantships (TAs) and Research Assistantships (RAs) are available on a competitive basis. In addition to tuition remission, assistantships include stipends for Ph.D. students.

Environmental Science

The environmental science graduate programs are offered through several departments at New Jersey Institute of Technology and at Rutgers Newark, collaborating in an interdisciplinary program of research and teaching. These are the departments of Chemistry and Environmental Science, Environmental Engineering and Environmental Policy at NJIT, the Federated Department of Biological Sciences, and the Rutgers-Newark Department of Earth & Environmental Sciences. The strong research program is supported by major grants from federal and state agencies, and industry. Environmental science plays a major role in several NJIT research centers, including the Otto York center for Environmental Engineering and Science.

Master of Science in Environmental Science

This is an interdisciplinary program intended for individuals with backgrounds in science or engineering who want advanced education in the identification, management, treatment and effects of hazardous and toxic materials in the environment. It may be taken on a part-time or full-time basis.

Admission Requirements

Applicants should have undergraduate degrees in chemistry, biology, chemical engineering, environmental engineering, environmental science, or related fields who have taken a minimum of one year of college chemistry and mathematics through calculus. Students who lack an appropriate background may be considered for admission and required to take a program of courses that is designed in consultation with the graduate advisor. These may include undergraduate courses which are not counted toward degree credit.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. Those applying for financial support and those whose last prior degree was from outside the United States must submit GRE scores. International students must achieve a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Environmental Science

This is a research-oriented degree intended for full-time students. Although courses may be taken on a part-time basis, a minimum of one year of full-time residency is typically required for completion of the doctoral dissertation.

Admission Requirements for Students Entering with a Master's Degree

A master's degree in chemistry, biology, chemical engineering, environmental engineering, environmental science, or related fields is usually required. Highly qualified students with bachelor's degrees in these fields may also be accepted directly into the doctoral program.

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Admission Requirements for Students Entering with a Bachelor's Degree

Exceptional students with appropriate undergraduate degrees may apply directly for admission to the doctoral program. Applicants are evaluated on a case-by-case basis. A minimum undergraduate GPA of 3.5 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Environmental and Sustainability Policy

The Graduate Program in Environmental and Sustainability Policy focuses on the role of the social sciences in the development, implementation, and evaluation of environmental policy. Building on the strengths of a technological university, students take a series of foundation courses (Tier One) in environmental social science, environmental science, research methods, and economics. Advanced courses (Tier Two) build on this initial framework and provide extensions in specific applications in environmental law, energy policy, and a selection of advanced topics.

The faculty is multidisciplinary with strengths in environmental social science, economics, geography, and law. Graduates of the program have secured employment in both the public and private sectors including with the United States Environmental Protection Agency, the New Jersey Department of Environmental Protection, regional planning commissions, local community development programs, and engineering and planning firms. Graduates have also entered doctoral- level programs in environmental science, policy, and law.

The Ph.D. in Environmental Science (Policy Concentration) is offered by the Department of Chemistry and Environmental Science of which the Graduate Program in Environmental Policy is a constituent part. Successful environmental policies must rest on the development of reliable models for assessing change to the biophysical environment in the presence of human action. The Department offers a research-oriented doctoral degree in Environmental Science with a concentration in Environmental Policy. The program emphasis is on the integration of environmental and social sciences to develop more effective responses to contemporary problems of resource management. For more information about degree requirements, please visit the website of the Department of Chemistry and Environmental Science.

Admission Requirements

The following criteria are applied when considering an applicant for admission to the program:

- An undergraduate degree in earth sciences (e.g. physical geography, geology, meteorology, ecology), social sciences (e.g. human geography, economics, sociology), engineering (e.g. environmental, civil, chemical) or another related discipline.
- An undergraduate GPA of at least 3.0 and at least 3.5 in major field (on a scale of 4.0).
- A minimum of one semester of statistics at the undergraduate level; an advanced statistics course at the undergraduate level is highly desirable.
- A combined GRE score (verbal and quantitative) of at least 1100

The following materials must be submitted to be considered for admission:

- Application for Admission to Graduate Study form
- MS-EPS Supplemental Materials form
- Official transcripts of all prior work and certificate of graduation
- Personal statement (two to three pages)
- Three letters of recommendation
- Graduate Record Examination (GRE) scores
- International students are required to pass the TOEFL at 550 (pencil and paper), 213 (computer based) or above.

NJIT Faculty

B

Belfield, Kevin D., Professor

Bonchonsky, Michael P., University Lecturer

Bozzelli, Joseph W., Distinguished Professor Emeritus

Butherus, Alexander D., University Lecturer

C

Champagne, Pier Alexandre, Assistant Professor

Chen, Hao, Professor

Conley, Robert J., Emeritus

D

DeSantis, Christopher, University Lecturer

F

Farinas, Edgardo T., Associate Professor

Fisher, David R., Professor of Practice

G

Getzin, Donald, Associate Professor Emeritus

Gulotta, Miriam, University Lecturer

Gund, Tamara M., Professor

J

Jackson, Nancy L., Professor

K

Kebbekus, Barbara B., Professor Emeritus

Khalizov, Alexei, Associate Professor

Kim, Yong I., Assistant Professor

Krasnoperov, Lev N., Professor

L

Lambert, Donald G., Associate Professor Emeritus

Lei, George Y., Associate Professor Emeritus

Li, Mengyan, Assistant Professor

M

Mitra, Somenath, Distinguished Professor

Momenitaheri, Mohammadreza, University Lecturer

P

Pacheco, Carlos N., Senior University Lecturer

Petrova, Roumiana S., Senior University Lecturer

Q

Qiu, Zeyuan, Professor

S

Sadik, Omowunmi A., Distinguished Professor

Shakib, Farnaz A., Assistant Professor

V

Venanzi, Carol A., Distinguished Professor Emeritus

Z

Zhang, Yuanwei, Assistant Professor

Programs

- Chemistry - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/chemistry-ms/)
- Environmental Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/)
- Pharmaceutical Chemistry - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/pharmaceutical-chemistry-ms/)

Programs

- Chemistry - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/chemistry-phd/)
- Environmental Science - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-phd/)

Chemistry and Environmental Science Courses

CHEM 590. Graduate Co-Op Work Exper I. 1 credit, 1 contact hour.

CHEM 591. Graduate Co-Op Work Exper II. 1 credit, 1 contact hour.

CHEM 592. Graduate Co-Op Work Exper III. 1 credit, 1 contact hour.

CHEM 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CHEM 599. Methods for Teaching Assistants and Graduate Assistants. 3 credits, 3 contact hours.
Restriction: graduate standing. Required for all chemistry teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

CHEM 601. Special Topics in Chemistry I. 3 credits, 3 contact hours.
Restriction: graduate standing and permission of the instructor. Topics of current interest in chemistry.

CHEM 605. Advanced Organic Chemistry I: Structure. 3 credits, 3 contact hours.
Prerequisite: undergraduate organic chemistry. Structure of organic molecules. Topics include atomic and molecular structure, stereochemistry, reactive intermediates (cations, anions, radicals, and carbenes), orbital symmetry, and spectroscopy.

CHEM 606. Physical Organic Chemistry. 3 credits, 3 contact hours.
Prerequisite: CHEM 502 or equivalent. Emphasis is placed on the physical aspects of the subject. Determination of reaction mechanisms, equilibria, and kinetics using simple molecular orbital theory and absolute reaction rate theory.

CHEM 610. Advanced Inorganic Chemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate physical chemistry or permission of the instructor. Theories of observed chemical and physical properties of the elements and their compounds; prediction of reactivity and properties of proposed new compounds.

CHEM 617. Mass Spectrometry and Interpretation of Mass Spectra. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM 126 or equivalent. Historical background, fundamentals and mechanics of operation for components incorporated into modern Mass Spectrometers: vacuum system, ion sources, mass filter, ion detection, plus computer operation and data collection. Explanation and interpretation of mass spectra and fragmentation patterns are a fundamental theme throughout the course. Lecture material includes principles of operation and appropriate applications for modern types of mass spectrometers: magnetic sector, quadrupole, time of flight, ion trap, FT-ICR. Theory and applications of electron impact, chemical, electrospray, and other ionization techniques including atmospheric sampling are covered. High resolution analysis using magnetic sector and FT - ion cyclotron instruments. Analytical applications in environmental, petroleum and biochemical analysis and applications and coupling of mass spectrometry with other instruments (GC, LC, AES,) are illustrated.

CHEM 658. Advanced Physical Chemistry. 3 credits, 3 contact hours.
Prerequisite: one year of undergraduate physical chemistry. Principles and applications of quantum chemistry; the wave equation, its properties and mathematics; the Schrodinger equation and wave functions; the harmonic oscillator; variational and perturbational methods; atomic theory, structure, and properties; simple molecules, LCAO and valence bond theories; semi-empirical methods; time dependence, and introduction to electronic and vibration-rotation spectroscopy.

CHEM 661. Instrumental Analysis Laboratory. 3 credits, 3 contact hours.
Prerequisite: one year of undergraduate physical chemistry. Instruments for chemical analysis are discussed in class and used in the laboratory; basic theory; sample preparation; use of instruments and interpretation of data are covered for spectroscopy including UV0VIS, FTIR, AA, and NMR; HPLC, GC, ion chromatography, mass spectrometry. Applications to food science, pharmaceuticals, polymers, and other chemical areas.

CHEM 662. Air Pollution Analysis. 3 credits, 4 contact hours.
Prerequisite: undergraduate physical chemistry. Chemical and physical principles of gaseous species and trace level measurement techniques for airborne vapors and particulates. Emphasis on analyzing real air samples at the parts-per-billion level, meteorological dispersion and life times of pollutants are covered. Laboratory work in air pollution sampling methods for vapor and particulate species. Determination of primary air pollutants using wet chemical and instrumental techniques.

CHEM 664. Advanced Analytical Chemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate physical chemistry. The principles of chemical analysis as they apply to chromatography, electrochemistry, and spectroscopy. Sampling considerations, separations, and sample preparation steps. This course is a useful adjunct to CHEM 661, where these analytical techniques are considered in a more practical way.

CHEM 673. Biochemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate organic and physical chemistry, or suitable background in these subjects. Fundamentals of biochemistry related to physical organic chemistry for students who have an interest in biomedical engineering, chemistry, chemical engineering, or environmental science.

CHEM 700. Masters Project. 0 credits, 0 contact hours.
Prerequisite: matriculation for the master's degree. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Approval to register for the master's project must be obtained from the project advisor. Students must continue to register for at least 3 credits each semester until the project is completed and a written report is accepted. Only a total of 3 credits will count toward the degree.

CHEM 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry. A written report must be submitted to the project advisor. The student cannot register in CHEM 700B more than once and the incomplete (I) grade is not allowed.

CHEM 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the master's degree in applied chemistry. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the department, and one other faculty member. Once registration for thesis has begun, a student must continue to register for a minimum of 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

CHEM 701B. Masters Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CHEM 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHEM 701C. Masters Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CHEM 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHEM 702. Special Topics in Chemistry II. 3 credits, 3 contact hours.
Restriction: Graduate standing. Topics of current interest in chemistry.

CHEM 714. Pharmaceutical Analysis. 3 credits, 3 contact hours.
The objective of this course is to provide an overview of instrumental techniques used in the analysis of different pharmaceutical products. Many different types of analysis are carried out in the pharmaceutical industry pertaining to active ingredients, formulations as well as impurities and dgradants. The focus will be on instrumentation such as chromatography, mass spectroscopy, different types of spectroscopy, quality assurance and GMP.

CHEM 716. Integrated Drug Dev & Discover. 3 credits, 3 contact hours.
Prerequisites: Strong background in organic chemistry This course offers an overview of the drug development process combined with hands-on experience in computer-aided drug design. Topics include pharmacokinetics, bioavailability, drug formulation, and structure-based drug design.

CHEM 717. Mass Spectrometry and Mass Spectral Interpretation. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM126 or equivalent. CHEM 717 and EVSC 617 are comprised of CHWM 717 and EVSC 617 plus a research project: Research projects usually comprise experimental and mass spectrometry interpretation studies. These can be performed at NJIT or in the students corporate mass spectrometry facility. Projects may also include theory, data interpretation or literature reviews pertinent to a current active area in mass spectrometry research. Projects should be approved or in consult with the instructors.

CHEM 718. Organic Synthesis. 3 credits, 3 contact hours.
Organic Synthesis is widely used in the production of organic materials and pharmaceutical drugs. The course introduces modern synthetic methods to the graduate students of NJIT. The first part of the course teaches organic reactions categorized by their roles in synthesis. Topics include substitution and addition of carbon nucleophiles, functional group conversion, oxidation, reduction, concerted cycloadditions, aromatic substitutions, and organometallic catalysis. The second part of the course teaches general strategies to develop synthetic plans, special considerations for difficult synthetic targets, and examples of natural product synthesis.

CHEM 719. Drug Delivery Systems. 3 credits, 3 contact hours.
Prerequisites: Strong background in organic chemistry This course emphasizes the importance of effective drug delivery to achieve specific therapeutic outcomes. Students learn current trends in research on the design of drug delivery systems to release drug content in a controllable and targeted manner.

CHEM 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CHEM 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for CHEM 726 if they have taken CHEM 725 in a prior semester.

CHEM 727. Independent Study III. 3 credits, 3 contact hours.
Restriction: written permission from the Associate Chairperson for Environmental Science plus courses prescribed by the supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which are not sufficiently broad to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHEM 734. Thermochemical Kinetics-Detailed Mechanistic Modeling. 3 credits, 3 contact hours.
Prerequisite: graduate level course in either kinetics or reactor design, or permission of instructor. Quantitative estimation of thermochemical data and chemical reactions in the vapor phase, and to some extent in the liquid phase; theories of transition state, RRKM, and Quantum RRK; and detailed chemical modeling concepts for reactor design. Applied computer project is required.

CHEM 735. Combustion. 3 credits, 3 contact hours.
Prerequisite: thermodynamics and kinetics or equivalent, or permission of instructor. Thermodynamic properties of stable molecules and free radical species in combustion and oxidation of aliphatic hydrocarbons; reactions occurring in high temperature combustion systems; and related kinetic principles.

CHEM 737. Applications of Computational Chemistry and Molecular Modeling. 3 credits, 3 contact hours.
Students are exposed to hands-on applications and fundamental aspects of computational chemistry and molecular modeling in organic, inorganic, bio- and physical chemistry. The course provides methods to determine the thermochemistry of a reaction, and strength (energy)of interactions by organic drug-like molecules with proteins. The course teaches the student to evaluate relative energy of different structures plus chemical species stability, reactivity and equilibrium ratios in chemical environments.

CHEM 748. Nanomaterials. 3 credits, 3 contact hours.
New feature of the 700 level course will be hands-on small projects carried out by groups of two students in Professor Iqbal's laboratories during the second half of the semester. The projects will be selected from the topics covered in the course. A second feature will involve a lecture on a specialized nanomaterial topic given by an invited outside lecturer. This 3 credit interdisciplinary course is designed to teach and provide hands-on project experience to M.S. and Ph.D. graduate students in chemistry, physics/materials science, and chemical/biomedical/electrical engineering on the fundamentals, synthesis, characterization and applications of nanomaterials. 75% of the course will comprise of lectures-one or two of which will be given by invited outside lecturers. 25% of the course will involve small projects based on the syllabus and conducted in the research laboratories of the instructor.

CHEM 764. Advanced Analytical Chemistry. 3 credits, 3 contact hours.
Prerequisites: undergraduate General and Analytical Chemistry. The principles of chemical analysis as they apply to chromatography, electrochemistry, and spectroscopy. Sampling considerations, separations, and sample preparation steps. This course is a useful adjunct to CHEM 661, where these analytical techniques are considered in a more practical way.

CHEM 777. Principles Pharm Chemistry. 3 credits, 3 contact hours.
Teaches about drug design, and the molecular mechanisms by which drugs act in the body. Covers pharmacodynamics, pharmacokinetics, molecular targets used by drugs, the interaction of a drug with a target, and the consequences of this interaction. Covers strategies used in discovering and designing new drugs, and surveys the "tools of the trade" involved, e.g., QSAR, combichem and computer aided design. Covers special topics like chlorinergics, analgesics, opiates, antibacterials, antivirals, and antiulcer agents.

CHEM 790. Doctoral Dissertation. 0 credits, 0 contact hours.

CHEM 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Co-requisite: CHEM 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry. For PhD students who have successfully defended their dissertation proposal. The student must register in CHEM 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

CHEM 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Co-requisite: CHEM 791. Since the CHEM 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in chemistry. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

CHEM 790C. Doctoral Dissertation. 6 credits, 6 contact hours.
Co-requisite: CHEM 791. Since the CHEM 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in chemistry. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

CHEM 790D. Doctoral Dissertation. 9 credits, 3 contact hours.

CHEM 790E. Doctoral Dissertation. 12 credits, 3 contact hours.

CHEM 790F. Doctoral Dissertation. 15 credits, 15 contact hours.

CHEM 790G. Doctoral Dissertation. 18 credits, 18 contact hours.

CHEM 791. Graduate Seminar. 0 credits, 0 contact hours.
Required of all chemistry graduate students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

CHEM 792. Pre-Doctoral Research. 3 credits, 3 contact hours.

CHEM 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: CHEM 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in chemistry. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

CHEM 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

EPS 601. Research Methods for Environment and Sustainability Policy. 3 credits, 3 contact hours.
Introduces the research methods necessary to conduct studies in environmental and sustainability policy. Topics covered include literature review, problem identification, hypothesis testing, and quantitative methods of data analysis and problem solving. Students are required to implement and present their independently designed projects.

EPS 602. Research Analysis for the Social and Policy Sciences. 3 credits, 3 contact hours.
Prerequisite: EPS 601. Distribution of social, political, economic and health-related data in both samples and populations using a general linear model with residuals. Test hypotheses using both the Fisher and Neyman-Pearson criteria. Use of software such as SPSS, Microsoft Excel and Resampling Stats. to develop and test models using correlation, regression and ANOV techniques.

EPS 609. Environmental Risk Assessment. 3 credits, 3 contact hours.
Methodology to assess the social and economic risks to present-day environmental resources of air and water; cost-benefit and trade-off analysis; technical characteristics of materials such as half-life, decomposition rates, and temperature sensitivity; and probabilities of various environmental situations.

EPS 612. Introduction to Environmental Policy Studies. 3 credits, 3 contact hours.
Introduction to six areas essential to a comprehensive understanding of environmental policy: concept of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio); industrial perspective (pollution prevention/life cycle engineering, privatization); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline.) Same as MIP 612.

EPS 613. Environmental History and Policy. 3 credits, 3 contact hours.
Explores the dialogue between humanity and the environment in the United States, as well as its global implications. Surveys fundamental themes of history and policy from an environmental perspective: colonial development, independence, western expansion, industrialization, urbanization, and the rise of a consumer society. Gives special attention to the emergence of an environmental perspective: wilderness appreciation, the conservation movement, public health, the rise of the environmental movement since the 1960s, environmental science, and the legislative and regulatory process.

EPS 614. Environmental Economics and Management. 3 credits, 3 contact hours.
Overviews the complex and dynamic interactions between the economy and the environment from biological, economic, and institutional perspectives and investigates various strategies for resolving conflicts in resource management and pollution control. Topics include the basic principles of risk assessment, cost benefit analysis, and cost-effectiveness analysis in environment management and assessment of contemporary environment politics in air and water pollution control and waste and toxics management.

EPS 622. Sustainable Politics and Policy. 3 credits, 3 contact hours.
Identifies the origins of the concept of sustainability development and institutional efforts to implement strategies at various geopolitical scales: international, national, regional, and local. The course introduces tools to measure progress toward sustainability through the use of metrics such as ecological footprint analysis and life-cycle analysis. Other topics include steady-state economics, sustainable systems of production and consumption, and sustainability transitions.

EPS 638. Physical Geography. 3 credits, 3 contact hours.
Understanding the interaction between humans and the physical environment is important to the formulation of sound environmental policy. The course examines processes that shape the physical environment, the influence of human activities on these processes and the physical environment, and the application of this information to solving environmental problems.

EPS 644. The Rhetoric of Environmental Policy. 3 credits, 3 contact hours.
Introduces students to the major types of rhetorical analysis as well as assures that students can analyze and write technology policy that is informed by core rhetorical principles of that analysis.

EPS 651. Introduction to Urban and Environmental Health. 3 credits, 3 contact hours.
Health problems associated with the social and psychological factors found in urban areas and health problems stemming from contamination of air, water, food, the work place and other special environments. Policies required to promote healthful living behavior and those required to regulate negative externalities.

EPS 660. Ethics and Environmental Policy. 3 credits, 3 contact hours.
Contemporary environmental problems from the perspective of ethics or moral philosophy. Is there a moral obligation to preserve or protect the natural environment? What are the ethical presumptions and values underlying environmental policy? Are traditional theories of moral philosophy applicable to contemporary environmental problems, or is a new conception of the relationship between humanity and nature needed?.

EPS 698. ST:. 3 credits, 3 contact hours.
Course considers advanced topics of special or current interest related to environmental and sustainability policy.

EPS 699. ST:. 3 credits, 3 contact hours.
Course considers advanced topics of special or current interest related to environmental and sustainability policy.

EPS 700. Master'S Project. 0 credits, 0 contact hours.

EPS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental and sustainability policy. A written report must be submitted to the project advisor. The student cannot register in EPS 700B more than once and the incomplete (I) grade is not allowed.

EPS 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the master's degree, advisor's and departmental approval. Projects involving fieldwork, experimental, or theoretical investigation carried out under the supervision of a designated member of the departmental faculty. The completed thesis should be of a quality as to warrant publication, in whole or in part, in a professional journal. A minimum of 3 credits per semester is required until completion.

EPS 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental and sustainability policy that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in EPS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EPS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental and sustainability policy that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (EPS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EPS 702. Special Topics. 3 credits, 3 contact hours.
Restriction: Approval of graduate advisor in Environmental Science. Topics of current interest in the field of environmental policy. Doctoral level course.

EPS 712. Advanced Studies in Environmental and Sustainability Policy. 3 credits, 3 contact hours.
Evaluates strategies to reduce energy and material throughput including eco-efficiency relocalization of production and consumption, and green consumerism. Also considered are debates surrounding innovative policies to foster work-time reduction, to develop alternative measures of well-being, and to include societal values shifts.

EPS 714. Environmental and Natural Resources Economics. 3 credits, 3 contact hours.
Examines environmental regulation of firms and natural resource use with emphasis on the theoretical foundations required for public policy. Students focus primarily on the application of economic tools to improve environmental quality.

EPS 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

EPS 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for EPS 726 if they have taken EPS 725 in a prior semester.

EVSC 591. Graduate Work Experience I. 1 credit, 1 contact hour.
Restriction: permission of the associate chairperson for environmental science and the Division of Career Development Services. Provides on-the-job reinforcement of environmental science assignments. Projects are developed by the co-op office in consultation with the associate chairperson for environmental science. Cannot be used for degree credit.

EVSC 592. Graduate Work Experience II. 1 credit, 1 contact hour.
Restriction: permission of the associate chairperson for environmental science and the Division of Career Development Services. Provides on-the-job reinforcement of environmental science assignments. Projects are developed by the co-op office in consultation with the associate chairperson for environmental science. Cannot be used for degree credit.

EVSC 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

EVSC 600. Environmental Science Seminar. 0 credits, 3 contact hours.
Restriction: graduate standing. Current environmental topics of interest to the environmental professional are presented. Required every semester for environmental science graduate students receiving departmental or research-based awards and for all doctoral students.

EVSC 602. Special Topics in Environmental Science I. 3 credits, 3 contact hours.
Restriction: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EVSC 603. Hazardous Waste Operations and Emergency Response. 3 credits, 3 contact hours.
Explores the safe operation of hazardous waste sites as well as emergency responses to hazardous releases. Overview of OSHA regulations and NIOSH standards concerning toxicological hazards and medical surveillance requirements. Emphasis on recognition and monitoring of site hazards. A written health and safety plan, and participation in a group problem involving a simulated hazardous site entry using actual protective equipment is required. Course satisfies the regulatory compliance mandates to meet 29 CFR 1910.120 for OSHA, with certification valid for one year.

EVSC 610. Environmental Chemical Science. 3 credits, 3 contact hours.
Restriction: graduate standing. Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.

EVSC 611. Hazardous Waste Management. 3 credits, 3 contact hours.
Restriction: graduate standing. An overview of hazardous waste management; case histories; legislation and regulations; treatment, disposal and cleanup technologies; sampling and analysis methodology; persistence and fate in the environment; emergency response procedures.

EVSC 612. Environmental Analysis. 3 credits, 4 contact hours.
Restriction: graduate standing. The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.

EVSC 613. Environmental Problem Solving. 3 credits, 3 contact hours.
Restriction: graduate standing. This course is designed to study solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.

EVSC 614. Quantitative Environmental Risk Assessment. 3 credits, 3 contact hours.
Restriction: graduate standing. Applications ofquantitative risk assessment concepts to the management of environmental problems.

EVSC 615. Global Environmental Problems. 3 credits, 3 contact hours.
Restriction: graduate standing. With an understanding that environmental problems are not restricted by geographical boundaries, relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies are studied.

EVSC 616. Toxicology. 3 credits, 3 contact hours.
Restriction: graduate standing. The general principles of toxicology are presented and applied to the assessment of acute, subacute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.

EVSC 617. Mass Spectrometry and Interpretation of Mass Spectra. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM 126 or equivalent. Historical background, fundamentals and mechanics of operation for components incorporated into modern Mass Spectrometers: vacuum system, ion sources, mass filter, ion detection, plus computer operation and data collection. Explanation and interpretation of mass spectra and fragmentation patterns are a fundamental theme throughout the course. Lecture material includes principles of operation and appropriate applications for modern types of mass spectrometers: magnetic sector, quadrupole, time of flight, ion trap, FT-ICR. Theory and applications of electron impact, chemical, electrospray, and other ionization techniques including atmospheric sampling are covered. High resolution analysis using magnetic sector and FT - ion cyclotron instruments. Analytical applications in environmental, petroleum and biochemical analysis and applications and coupling of mass spectrometry with other instruments (GC, LC, AES,) are illustrated.

EVSC 621. Ecological Risk Assessment. 3 credits, 3 contact hours.

EVSC 622. Bioremediation. 3 credits, 3 contact hours.

EVSC 623. Environmental Health. 3 credits, 3 contact hours.

EVSC 624. Environmental Analysis Methods and Laboratory. 3 credits, 4 contact hours.
Basic theory, methods, instruments, and data interpretation for chemical analysis of environmental samples are described in lectures and used in the laboratory; sampling; sample preparation; quality assurance, chain of custody. Instrument methods and uses include: UV-VIS, FTIR, AA, HPLC, GC, Ion Chromatography, and Mass Spectrometry as applied to environmental samples.

EVSC 625. Social Dimensions of Risk. 3 credits, 3 contact hours.
Low-probability/high consequence events involving terrorism, food safety, and extreme weather offer ample evidence the prevalent approaches of economics and statistics are not able to deal with the complex ways that risk permeates modern societies. This course treats risk analysis as a broad interdisciplinary activity and draws on the full range of the social sciences to explore the multifaceted way that risk infuses itself into the fabric of contemporary affairs.

EVSC 626. Hydrogeology. 3 credits, 3 contact hours.
This course covers the principles of ground water flow, advanced water cycle properties, aquifer flow and aquifer recharge. Contaminant migration and remediation methods are discussed. Basic groundwater chemistry and quality is covered.

EVSC 627. Environmental Microbiology. 3 credits, 3 contact hours.
Prerequisites: R120 101, R120 102, (General Biology I and II) or permission of instructor. This course offers an overview of 1) basic microbiology: biochemical principles, cell structure organization, microbial nutrition and growth, 2) the important microbes involved in environmental microbiology and address the environments where they are found, and 3) how they are detected and monitored, and their effects on humans, and the environment. Traditional lectures and exams are supplemented with discussions of current research articles.

EVSC 700. Masters Project. 0 credits, 0 contact hours.
Prerequisite: graduate standing and approval of the graduate advisor in environmental science. Written report requiring experimental or theoretical research, or an extensive literature analysis. Registration must be approved by an advisor. Students must continue to register for 3 credits each semester until completion and a written report is accepted. Only a total of 3 credits will count toward the degree.

EVSC 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science. A written report must be submitted to the project advisor. The student cannot register in EVSC 700B more than once and the incomplete (I) grade is not allowed.

EVSC 701. Masters Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for a master's degree in environmental science. Approval to register for the thesis must be obtained from the advisor. Original research under the supervision of a designated faculty member. The final product must be a written thesis approved by three faculty members: the student's primary advisor, another from the program and one other faculty member. Once registration for thesis has begun, a student must continue to register for a minimum 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

EVSC 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in EVSC 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EVSC 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (EVSC 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EVSC 702. Special Topics in Environmental Science II. 3 credits, 3 contact hours.
Restriction: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EVSC 711. Advanced Environmental Analysis. 3 credits, 3 contact hours.
Prerequisite: EVSC 612 or equivalent. Analysis of complex environmental samples is studied, from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis and data handling. Collection and analysis of samples from air, water, soil, and biological systems will be discussed. Emphasis on the study of current literature.

EVSC 712. Hazardous Substance Management. 3 credits, 3 contact hours.
Restriction: Graduate standing. The course material comprises an overview of hazardous materials and hazardous waste management and control in an industrial setting. The course examines the technical approaches utilized in the control, remediation, and prevention of hazardous substances and waste. It also includes the major technical elements of federal regulations that govern operations involving the handling of hazardous materials.

EVSC 715. Energy and Sustainability. 3 credits, 3 contact hours.
This course comprises an interdisciplinary review of energy fundamentals including the basic principles necessary to understand energy systems. The technological and engineered systems for processing and using different energy non-renewable and renewable sources. The social and environmental consequences of energy production, distribution, and use, including a comparison of socioeconomic models of global energy applications.

EVSC 717. Mass Spectrometry and Mass Spectral Interpretation. 3 credits, 3 contact hours.
Prerequisites: CHEM 125 and CHEM 126 or equivalent. CHEM 717 and EVSC 617 are comprised of CHEM 717 and EVSC 617 plus a research project: Research projects usually comprise experimental and mass spectrometry interpretation studies. These can be performed at NJIT or in the students corporate mass spectrometry facility. Projects may also include theory, data interpretation or literature reviews pertinent to a current active area in mass spectrometry research. Projects should be approved or in consult with the instructors.

EVSC 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

EVSC 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for EVSC 726 if they have taken EVSC 725 in a prior semester.

EVSC 790. Doctoral Dissertation. 0 credits, 0 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Co-requisite: EVSC 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science. For PhD students who have successfully defended their dissertation proposal. The student must register in EVSC 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

EVSC 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Co-requisite: EVSC 791. Since the EVSC 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental science. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

EVSC 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: EVSC 791. Since the EVSC 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in environmental science. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

EVSC 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 790F. Doctoral Dissertation. 15 credits, 15 contact hours.
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

EVSC 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all environmental science graduate students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

EVSC 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: EVSC 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in environmental science. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ENVIRONMENTAL SCIENCE

It may sound surprising, but the environment is much cleaner today that it used to be 50 years ago. Thick smog is gone from the air and the rivers do not catch fire anymore. How did the co-existence of continuous economic development and cleaner environment become possible? The Graduate Certificate in Environmental Science will help students to develop an understanding of real-world environmental issues from an integrated science-technology-regulatory practice prospective. The program includes in depth understanding of local, regional, and global events, ranging from lead contamination of the Flint, MI water supply, to the environmental implications of climate change and stratospheric ozone depletion. Methods of gaining scientific understanding of the causes of these problems and developing policy regulations for their amelioration are described. Furthermore, examples are given of how the successful science-policy-technology approach can be applied to resolve other outstanding problems that the world is facing today, such as the unprecedented climate change caused by the release of carbon dioxide from combustion of fossil fuels. The curriculum provides an in depth understanding of environmental chemistry, pollution issues, toxicity of pollutants, methods for waste treatment and environmental law.

Who would be suited to take this program?

This program is designed for professionals, particularly of Chemistry, Environmental Science, Biology, or Engineering-based backgrounds, in the areas of Water Quality, Marine, Environmental Health, Air Pollution Control, Natural Resource Conservation, Waste Treatment or Environmental Health. Example occupations may include Environmental Consultants, Environmental Health and Safety Professional, Chemical and Pharmaceutical Industry Professionals, Health Practitioners, Estate Managers, Landscape Architect, Town Planners, Toxicologists, and Transportation Planners.

What are the Required Courses?

Code	Title	Credits
Core Courses		**12**
Select four (4) of the following:		
EVSC 610 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 610)	Environmental Chemical Science	
EVSC 612 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 612)	Environmental Analysis	
EVSC 613 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 613)	Environmental Problem Solving	
EVSC 615 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 615)	Global Environmental Problems	
EVSC 616 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 616)	Toxicology	
EVSC 627 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 627)	Environmental Microbiology	

EVSC 715 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 715)	Energy and Sustainability
EM 631 (http://catalog.njit.edu/archive/2019-2020/search/?P=EM 631)	Legal Aspects in Environmental Engineering
EPS 622 (http://catalog.njit.edu/archive/2019-2020/search/?P=EPS 622)	Sustainable Politics and Policy

What will I learn?

- ***Environmental Chemical Science* -** Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.
- ***Environmental Analysis*** - The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.
- ***Environmental Problem Solving*** - Solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.
- ***Global Environmental Problems*** - Relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies.
- ***Toxicology*** - The assessment of acute, sub-acute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.
- ***Environmental Microbiology* -** 1) basic microbiology: biochemical principles, cell structure organization, microbial nutrition and growth, 2) the important microbes involved in environmental microbiology and address the environments where they are found, and 3) how they are detected and monitored, and their effects on humans, and the environment.
- ***Energy and Sustainability* -** Energy fundamentals including the basic principles necessary to understand energy systems. The technological and engineered systems for processing and using different energy non-renewable and renewable sources. The social and environmental consequences of energy production, distribution, and use, including a comparison of socioeconomic models of global energy applications.
- ***Legal Aspects in Environmental Engineering* -** Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.
- ***Sustainable Politics and Policy* -** Sustainability development and institutional efforts to implement strategies at various geopolitical scales: international, national, regional, and local. The course introduces tools to measure progress toward sustainability through the use of metrics such as ecological footprint analysis and life-cycle analysis.

Why study Environmental Science at NJIT?

Not only do these courses help students to earn credits toward a Master's Degree in Environmental Science at NJIT, but they enable students to quickly engage in research in this field. From this academic department, Distinguished Professor Dr. Somenath Mitra is one of NJIT's most decorated faculty after receiving the 2017 Benedetti Pichler Award following his research on carbon nanotube water filtration in the desalination process, earning NJIT a patent. Students in this program may be able to work with him directly.

Into what industries might holders of this program find employment?

- Federal/State/Local Department of Environmental Protection (e.g., USDEP, NJDEP)
- Private consulting company conducting audits/reviews in environmental science
- Medical Centers

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (biology, chemistry, environmental science, environmental engineering, mathematics, etc.).

Related Degree Programs

The Graduate Certificate in Environmental Science relates entirely to the NJIT MS in Environmental Science (https://catalog.njit.edu/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/).

Faculty Advisor: Linda Cummings (https://chemistry.njit.edu/people/)

ENVIRONMENTAL SCIENCE AND ENGINEERING

A combination of both science and engineering, the Graduate Certificate in Environmental Science and Engineering at NJIT helps students solve environmental issues from both a scientific point of view as well as from an engineering point of view. The program will ultimately force a mathematical mindset to employ the scientific method when monitoring and solving real world environmental issues.

Who would be suited to take this program?

Due to the nature of engineering courses, one would want to possess an engineering background in order to be eligible for this program. Participants are typically employees of major corporations, government agencies, private consulting and construction firms, and universities.

What are the Required Courses?

Code	Title	Credits
Core Courses: choose four (4) courses in total, two (2) courses from each group.		**12**
Select two (2) of the following:		6
EVSC 610 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 610)	Environmental Chemical Science	
EVSC 612 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 612)	Environmental Analysis	
EVSC 613 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 613)	Environmental Problem Solving	
EVSC 615 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 615)	Global Environmental Problems	
EVSC 616 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 616)	Toxicology	
EVSC 627 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 627)	Environmental Microbiology	
EVSC 715 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 715)	Energy and Sustainability	
EM 631 (http://catalog.njit.edu/archive/2019-2020/search/?P=EM 631)	Legal Aspects in Environmental Engineering	
EPS 622 (http://catalog.njit.edu/archive/2019-2020/search/?P=EPS 622)	Sustainable Politics and Policy	
Select two (2) of the following:		6
ENE 630 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 630)	Physical Processes of Env Syst.	
ENE 661 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 661)	Environmental Microbiology	
ENE 662 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 662)	Site Remediation	

ENE 664 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 664)	Physical and Chemical Treatment
ENE 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 665)	Biological Treatment
ENE 671 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 671)	Environmental Impact Analysis
ENE 672 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 672)	Stormwater Management
CE 647 (http://catalog.njit.edu/archive/2019-2020/search/?P=CE 647)	Geotechnical Aspects of Solid Waste
EM 631 (http://catalog.njit.edu/archive/2019-2020/search/?P=EM 631)	Legal Aspects in Environmental Engineering

What will I learn?

- ***Environmental Chemical Science* -** Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.
- ***Environmental Analysis*** - The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.
- ***Environmental Problem Solving*** - Solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.
- ***Global Environmental Problems*** - Relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies.
- ***Toxicology*** - The assessment of acute, sub-acute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.
- ***Environmental Microbiology* -** 1) basic microbiology: biochemical principles, cell structure organization, microbial nutrition and growth, 2) the important microbes involved in environmental microbiology and address the environments where they are found, and 3) how they are detected and monitored, and their effects on humans, and the environment.
- ***Energy and Sustainability* -** Energy fundamentals including the basic principles necessary to understand energy systems. The technological and engineered systems for processing and using different energy non-renewable and renewable sources. The social and environmental consequences of energy production, distribution, and use, including a comparison of socioeconomic models of global energy applications.
- ***Legal Aspects in Environmental Engineering* -** Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.
- ***Sustainable Politics and Policy* -** Sustainability development and institutional efforts to implement strategies at various geopolitical scales: international, national, regional, and local. The course introduces tools to measure progress toward sustainability through the use of metrics such as ecological footprint analysis and life-cycle analysis.
- ***Physical Processes of Environmental Systems* -** Physical processes in various media (open water, porous media) under various hydraulic regimes (laminar and turbulent). Transport by diffusion, convection, and dispersion is considered along with absorption.
- ***Environmental Microbiology* -** Microbiology of natural and human impacted environment, fundamental microbiology in water treatment engineering, microbial detection methodologies, waterborne disease outbreaks, microbial risk assessment, biotechnologies for renewable energy, and other emerging topics
- ***Site Remediation* -** Regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Established and innovative cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.

- ***Physical and Chemical Treatment -*** Physical and chemical operations and processes employed in the treatment of water and wastewater. Gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.
- ***Biological Treatment -*** Principles of evaluation and control of water pollution that describe aerobic treatment processes such as oxidation ponds, trickling filters, and activated sludge; and anaerobic processes, and sludge handling and disposal as wall as biodegradability study techniques for various wastes.
- ***Environmental Impact Analysis -*** Environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.
- ***Stormwater Management -*** With an emphasis on design practices, you will learn regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.
- ***Geotechnical Aspects of Solid Waste -*** municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems.

Why study Environmental Science and Engineering at NJIT?

This hybrid program allows for individuals to learn from both a theoretical point of view as well as a practical one. Students will learn to develop sustainable solutions to environmental problems, preparing to work with regional, national and global communities to protect the environment and improve water quality. Jobs in this field are essential in planning, designing and constructing water and wastewater treatment plants, solid waste disposal systems, site remediation approaches and emission control measures.

Into what industries might holders of this program find employment?

- Federal/State/Local Department of Environmental Protection (e.g., USDEP, NJDEP)
- Private consulting company conducting audits/reviews in environmental science
- Medical Centers
- Junior Civil Engineer
- Sr. Transportation Engineering Manager
- Hydrologist

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (biology, chemistry, environmental science, environmental engineering, mathematics, etc.).

Related Degree Programs

Depending on the courses selected, coursework would apply to either the NJIT MS in Environmental Science (https://catalog.njit.edu/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/) or the NJIT MS in Environmental Enginering (https://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-ms/).

Faculty Advisor: Linda Cummings (https://chemistry.njit.edu/people/)

M.S. in Chemistry

Degree Requirements

A minimum of 30 degree credits is required. Students must attain a cumulative GPA of 3.0 or better in the core courses listed below, and a minimum overall GPA of 3.0.

Seminar: In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in CHEM 791 Graduate Seminar.

M.S. in Chemistry (courses only)

Code	Title	Credits
Core Courses		
CHEM 605	Advanced Organic Chemistry I: Structure	3
CHEM 661	Instrumental Analysis Laboratory	3
or CHEM 664	Advanced Analytical Chemistry	
CHEM 610	Advanced Inorganic Chemistry	3

or CHEM 673	Biochemistry	
CHEM 658	Advanced Physical Chemistry	3
Elective Courses		
Two 600- or 700-level chemical engineering or chemistry courses		6
Four electives [1]		12
Total Credits		30

1 A maximum of 6 elective credits may be taken from outside chemistry or chemical engineering; a maximum of 3 credits may be at the 500 level.

M.S. in Chemistry (Master's thesis)

Code	Title	Credits
Core Courses		
CHEM 605	Advanced Organic Chemistry I: Structure	3
CHEM 661	Instrumental Analysis Laboratory	3
or CHEM 664	Advanced Analytical Chemistry	
CHEM 610	Advanced Inorganic Chemistry	3
or CHEM 673	Biochemistry	
CHEM 658	Advanced Physical Chemistry	3
Thesis [1]		
CHEM 701B & 701B	Masters Thesis and Masters Thesis	6
or CHEM 701C	Masters Thesis	
Elective Courses [2]		
Four electives		12
Total Credits		30

1 Required of those receiving departmental or research-based support.

2 A maximum of 6 elective credits may be taken from outside chemistry or chemical engineering; a maximum of 3 credits may be at the 500 level.

M.S. in Environmental Science

Degree Requirements

A minimum of 30 degree credits is required. Candidates must consult with the graduate advisor (not thesis advisor) in designing appropriate programs of study.

Students must attain a minimum GPA of 3.0 in the core courses listed below, and a minimum overall GPA of 3.0.

Seminar: In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in EVSC 600 Environmental Science Seminar.

M.S. in Environmental Science (courses only)

Code	Title	Credits
Core Courses		
EM 631	Legal Aspects in Environmental Engineering	3
EVSC 610	Environmental Chemical Science	3
EVSC 612	Environmental Analysis	3
EVSC 616	Toxicology	3
EVSC 627	Environmental Microbiology	3
Elective [1]		
Select five of the following:		15
EVSC 602	Special Topics in Environmental Science I	
EVSC 611	Hazardous Waste Management	
EVSC 613	Environmental Problem Solving	
EVSC 614	Quantitative Environmental Risk Assessment	

EVSC 615	Global Environmental Problems	
EVSC 700	Masters Project	
EVSC 702	Special Topics in Environmental Science II	
EVSC 711	Advanced Environmental Analysis	
EVSC 725	Independent Study I	
EVSC 726	Independent Study II	
ENE 673	Sustainability and Life Cycle Analysis	
ENE 672	Stormwater Management	
ENE 660	Introduction to Solid and Hazardous Waste Problems	
ENE 662	Site Remediation	
ENE 664	Physical and Chemical Treatment	
ENE 665	Biological Treatment	
CE 602	Geographic Information System	
CHEM 664	Advanced Analytical Chemistry	
R120 551	Biology Of Pollution	
R120 522	Resource Sustainability	
R120 534	Biological Invasion	
R120 523	Scale Of Biodiversity	
IE 615	Industrial Hygiene and Occupational Health	
EPS 612	Introduction to Environmental Policy Studies	
EPS 622	Sustainable Politics and Policy	
EPS 614	Environmental Economics and Management	
EPS 638	Physical Geography	
Total Credits		30

[1] Courses are offered at NJIT and Rutgers-Newark and selected with the graduate advisors (not thesis advisors) approval.

M.S. in Environmental Science (Master's thesis)

Code	Title	Credits
Core Courses		
EM 631	Legal Aspects in Environmental Engineering	3
EVSC 610	Environmental Chemical Science	3
EVSC 612	Environmental Analysis	3
EVSC 616	Toxicology	3
EVSC 627	Environmental Microbiology	3
Thesis [1]		
EVSC 701B & 701B	Master's Thesis and Master's Thesis	6
or EVSC 701C	Master's Thesis	
Elective [2]		
Select three of the following:		9
EVSC 602	Special Topics in Environmental Science I	
EVSC 611	Hazardous Waste Management	
EVSC 613	Environmental Problem Solving	
EVSC 614	Quantitative Environmental Risk Assessment	
EVSC 615	Global Environmental Problems	
EVSC 700	Masters Project	
EVSC 702	Special Topics in Environmental Science II	
EVSC 711	Advanced Environmental Analysis	
EVSC 725	Independent Study I	
EVSC 726	Independent Study II	
ENE 673	Sustainability and Life Cycle Analysis	
ENE 672	Stormwater Management	

ENE 660	Introduction to Solid and Hazardous Waste Problems	
ENE 662	Site Remediation	
ENE 664	Physical and Chemical Treatment	
ENE 665	Biological Treatment	
CE 602	Geographic Information System	
CHEM 664	Advanced Analytical Chemistry	
R120 551	Biology Of Pollution	
R120 522	Resource Sustainability	
R120 534	Biological Invasion	
R120 523	Scale Of Biodiversity	
IE 615	Industrial Hygiene and Occupational Health	
EPS 612	Introduction to Environmental Policy Studies	
EPS 622	Sustainable Politics and Policy	
EPS 614	Environmental Economics and Management	
EPS 638	Physical Geography	
Total Credits		30

1 Required of those receiving departmental or research-based support.

2 Courses are offered at NJIT and Rutgers-Newark and selected with the graduate advisors (not thesis advisors) approval.

M.S. in Pharmaceutical Chemistry

M.S. in Pharmaceutical Chemistry

The Master of Science in Pharmaceutical Chemistry provides advanced graduate training in the pharmaceutical and health sciences. The program provides professional training in quantitative methods that prepares graduates for careers in the medical, pharmaceutical, environmental, and biotechnology industries.

The M.S. in Pharmaceutical Chemistry requires 30 credits and includes 15 credit hours of core technical courses and 15 credit hours of technical electives. Co-op work experience and independent research may be used in place of certain technical electives, pending advisor approval.

Code	Title	Credits
Required Core Courses		
BIOL 605	Prin of Bioscience Processing	3
CHEM 605	Advanced Organic Chemistry I: Structure	3
CHEM 673	Biochemistry	3
CHEM 714	Pharmaceutical Analysis	3
CHEM 777	Principles Pharm Chemistry	3
Select five of the following:		15
BIOL 606	App Bioproc & Immun Based Ther	
CHEM 610	Advanced Inorganic Chemistry	
CHEM 658	Advanced Physical Chemistry	
CHEM 661	Instrumental Analysis Laboratory	
CHEM 716	Integrated Drug Dev & Discover	
CHEM 719	Drug Delivery Systems	
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	
CHEM 748	Nanomaterials	
EVSC 616	Toxicology	
MATH 663	Introduction to Biostatistics	
MATH 664	Methods for Statistical Consulting	
PHEN 500	Pharmaceutical Engineering Fundamentals I	
PHEN 601	Principles of Pharmaceutical Engineering	
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	
PHEN 618	Principles of Pharmacokinetics and Drug Delivery	
R120 572	Concepts in Pharm Drug Dev	

R160 515	Chem Struct Determin	
RBHS course - PATH N5209 Business of Science: Drug Development from Molecules to Medicines		
RBHS course - PHPY N5021 Fundamentals of Pharmacology		
Total Credits		30

M.S. in Pharmaceutical Chemistry PSM (Professional Science Master's) Biotechnology Option

This program option is affiliated with the National PSM Office. The objective of the option is to create leaders with strong communication and management skills in addition to strong technical knowledge in biotechnology in order to meet the needs of the rapidly changing biopharmaceutical industry. This option is designed for working professionals or students who already have acquired some professional experience.

This option requires 30 credits and includes 15 credit hours of core technical courses, 9 credit hours of professional courses (technical and professional communications, project management, intellectual property, or organizational behavior), 3 credit hours of co-op internship, and 3 credit hours of a technical elective.

Code	Title	Credits
Required Core Courses		
BIOL 605	Prin of Bioscience Processing	3
BIOL 606	App Bioproc & Immun Based Ther	3
CHEM 605	Advanced Organic Chemistry I: Structure	3
CHEM 673	Biochemistry	3
CHEM 777	Principles Pharm Chemistry	3
Required Professional Courses		
Select three of the following:		9
EM 631	Legal Aspects in Environmental Engineering	
EM 633	Legal Aspects of Health and Safety	
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 636	Project Management	
EVSC 613	Environmental Problem Solving	
EVSC 614	Quantitative Environmental Risk Assessment	
EVSC 623	Environmental Health	
IE 615	Industrial Hygiene and Occupational Health	
HRM 601	Organizational Behavior	
MGMT 620	Management of Technology	
PTC 601	Advanced Professional and Technical Communication	
PTC 620	Proposal Writing	
PTC 725	Independent Study in Professional and Technical Communication	
Required Experiential Capstone		
CHEM 590	Graduate Co-Op Work Exper I	
Elective Courses		
Select one of the following:		3
CHEM 658	Advanced Physical Chemistry	
CHEM 661	Instrumental Analysis Laboratory	
CHEM 700B	Masters Project	
CHEM 714	Pharmaceutical Analysis	
CHEM 716	Integrated Drug Dev & Discover	
CHEM 719	Drug Delivery Systems	
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	
CHEM 748	Nanomaterials	
EVSC 616	Toxicology	
MATH 663	Introduction to Biostatistics	
PHB 610	Biotechnology-Biopharmaceutical, Processes and Products	
PHB 615	Bioseparation Processes	

PHEN 500	Pharmaceutical Engineering Fundamentals I	
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	
PHEN 618	Principles of Pharmacokinetics and Drug Delivery	
R120 572	Concepts in Pharm Drug Dev	
R160 515	Chem Struct Determin	
RBHS course - PATH N5209 Business of Science:Drug Dev from Molecules to Medicine		
RBHS course - PHPY N5021 Fundamentals of Pharmacology		
Total Credits		27

Ph.D. in Chemistry

Ph.D. in Chemistry

Independent Learning

The grounding in scientific research methodology provided by the dissertation requirement is a central focus of the PhD program. One of the primary means of education and training in the PhD program is achieved through successful completion of an original research project in close mentorship by their research adviser and the presentation and defense of the PhD dissertation. This intense research experience provides the education and training necessary for the student to substantiate his/her expertise and develop the skills necessary to become an independent professional. By the end of the second semester, students will choose a dissertation adviser. Students will conduct research either on site at NJIT or at the professional laboratories where they work. In either case, a member of the NJIT Department of Chemistry and Environmental Science faculty will serve as research adviser and approve the research topic. This research culminates in the writing and presentation of the dissertation. The student will present his/her dissertation for examination by a committee consisting of a minimum of five members including the research adviser. One of the committee members will be from outside the department. A majority of the program committee members will hold tenure-earning faculty appointments in the Department of Chemistry and Environmental Science. The committee has to be approved by the director of the PhD chemistry graduate program, the department chair and the Office of Graduate Studies. With the exception of the outside member, the other committee members need to have graduate faculty status. The dissertation must be judged worthy of publication by the dissertation committee and may not be submitted for examination until so deemed. For students performing their dissertation research off campus, the dissertation adviser will visit the student’s laboratory, where their research is to be performed, before the research begins and on a regular basis until the work is complete.

Total Minimum Hours Required for PhD for students entering with Bachelor’s Degree (without MS degree) - 36 Credit Hours of 600/700-level Courses

Total Minimum Hours Required for PhD for students entering with MS degree - 12 Credit Hours of 700-level Courses

I. For Students Entering Without a MS Degree

Code	Title	Credits
Required Courses		**12**
Take four of the following five core courses:		
CHEM 605	Advanced Organic Chemistry I: Structure	
CHEM 610	Advanced Inorganic Chemistry	
CHEM 658	Advanced Physical Chemistry	
CHEM 661	Instrumental Analysis Laboratory	
CHEM 673	Biochemistry	
If a student successfully completes all five core courses, one course will count towards fulfilling the electives requirement. Students must maintain a 3.0 GPA or higher.		
Elective Courses		**24**
Students are required to take a minimum of eight 600- or 700-level courses (24 credit hours) with at least four (12 credit hours) of these at the 700-level. Courses are to be chosen from the departmental offerings while up to six credit hours may be selected from outside of the department. Up to six credit hours of Independent Study courses may be earned in fulfillment of the elective courses requirement.		
CHEM 714	Pharmaceutical Analysis	
CHEM 716	Integrated Drug Dev & Discover	
CHEM 719	Drug Delivery Systems	
CHEM 725	Independent Study I	
CHEM 726	Independent Study II	
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	
CHEM 748	Nanomaterials	
CHEM 764	Advanced Analytical Chemistry	

CHEM 777	Principles Pharm Chemistry	
CHE 681	Polymerization-Principles and Practice	
CHE 724	Sustainable Energy	
EVSC 622	Bioremediation	
EVSC 712	Hazardous Substance Management	
EVSC 715	Energy and Sustainability	
BIOL 645	Biological Imaging Techniques	
BME 651	Principles of Tissue Engineering	
BME 653	Micro/Nanotechnologies for Interfacing Live Cells	
BME 668	Medical Imaging Systems	
BME 672	Biomaterials	
BME 772	Adv Biomats for Lab and Clinic	
MTSE 719	Physical Principles of Characterization of Solids	
MTSE 722	Science and Technology of Thin Films	
MTSE 724	Transport of Electrons and Phonons in Solids	
MTSE 725	Crystallography and Diffraction	
MTSE 780	Current Topics in Materials Science and Engineering	
Total Credits		36

Dissertation Research Credits

CHEM 792 Pre-Doctoral Research (after completing qualifying exam requirements)
CHEM 790 Doctoral Dissertation (after completing research proposal requirements)

Qualifying Examination

By the end of the second year, students must pass the PhD qualifying oral examination. A student is given two chances to clear the exam. The qualifying examination consists of writing and orally defending an original research proposal to the student's dissertation committee in which the committee conducts an oral exam of the candidate (majority vote of the committee required). The original research proposal will focus on a topic not directly related to the student's dissertation research and must be approved by the dissertation committee prior to development of the proposal. Failure to pass the PhD qualifying exam will result in dismissal from the program.

Dissertation Research Proposal

By the end of the first year of passing the qualifying exam, students must successfully present a proposal of their dissertation research to their dissertation committee and gain approval by a majority vote of the committee.

Dissertation Defense

The final requirement for the PhD degree is completion of a satisfactory written dissertation of the student's research, along with successful presentation and defense of the dissertation to the student's dissertation committee (majority vote of the committee).

II. For Students Entering With a MS Degree

Students with a recognized MS degree in the chemical sciences or closely related field may, with approval of the PhD Chemistry Graduate Committee, be admitted to pursue the PhD degree in chemistry and be required to earn a minimum of 12 credit hours of coursework at the 700-level. In cases where a student with a previous MS degree is not approved to pursue this (accelerated) program, they will follow the program outlined in I above and be eligible to transfer up to nine credit hours from previous graduate courses, similar to students that have prior graduate course credits but no MS degree.

Code	Title	Credits
Elective Courses		**12**
Students are required to take a minimum of four 700-level courses (12 credit hours). Courses are to be chosen from the departmental offerings while up to three credit hours may be selected from outside of the department.		
CHEM 714	Pharmaceutical Analysis	
CHEM 716	Integrated Drug Dev & Discover	
CHEM 719	Drug Delivery Systems	
CHEM 725	Independent Study I	
CHEM 726	Independent Study II	
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	
CHEM 748	Nanomaterials	

CHEM 764	Advanced Analytical Chemistry
CHEM 777	Principles Pharm Chemistry
CHE 724	Sustainable Energy
EVSC 712	Hazardous Substance Management
EVSC 715	Energy and Sustainability
BME 772	Adv Biomats for Lab and Clinic
MTSE 719	Physical Principles of Characterization of Solids
MTSE 722	Science and Technology of Thin Films
MTSE 724	Transport of Electrons and Phonons in Solids
MTSE 725	Crystallography and Diffraction
MTSE 780	Current Topics in Materials Science and Engineering
Total Credits	12

Dissertation Research Credits

CHEM 792 Pre-Doctoral Research (after completing qualifying exam requirements)
CHEM 790 Doctoral Dissertation (after completing research proposal requirements)

Qualifying Examination

By the end of the third semester, students must pass the PhD qualifying oral examination. A student is given two chances to clear the exam. The qualifying examination consists of writing and orally defending an original research proposal to the student's dissertation committee in which the committee conducts an oral exam of the candidate (majority vote of the committee). The original research proposal will focus on a topic not directly related to the student's dissertation research and must be approved by the adviser and advisory committee prior to development of the proposal. Failure to pass the PhD proficiency exam will result in dismissal from the program.

Dissertation Research Proposal

Within a year of passing the qualifying exam, students must successfully present a proposal of their dissertation research to their dissertation committee and gain approval by a majority vote of the committee.

Dissertation Defense

The final requirement for the PhD degree is completion of a satisfactory written dissertation of the student's research, along with successful presentation and defense of the dissertation to the student's dissertation committee (majority vote of the committee).

Grades

All students must maintain a grade point average of at least 3.0.

Ph.D. in Environmental Science

Ph.D. in Environmental Science

Independent Learning

The grounding in scientific research methodology provided by the dissertation requirement is a central focus of the PhD program. One of the primary means of education and training in the PhD program is achieved through successful completion of an original research project in close mentorship by their research adviser and the presentation and defense of the PhD dissertation. This intense research experience provides the education and training necessary for the student to substantiate his/her expertise and develop the skills necessary to become an independent professional. By the end of the second semester, students will choose a dissertation adviser. Students will conduct research either on site at NJIT or at the professional laboratories/ organizations where they work. In either case, a member of the NJIT Department of Chemistry and Environmental Science faculty will serve as research adviser and approve the research topic. This research culminates in the writing and presentation of the dissertation. The student will present his/her dissertation for examination by a committee consisting of a minimum of five members including the research adviser. One of the committee members will be from outside the department. A majority of the program committee members will hold tenure-earning faculty appointments in the Department of Chemistry and Environmental Science. The committee has to be approved by the director of the PhD Environmental Science graduate program, the department chair and the Office of Graduate Studies. With the exception of the outside member the other committee members need to have graduate faculty status. The dissertation must be judged worthy of publication by the dissertation committee and may not be submitted for examination until so deemed. For students performing their dissertation research off campus, the dissertation adviser will visit the student's laboratory/organization, where their research is to be performed, before the research begins and on a regular basis until the work is complete.

Total Minimum Hours Required for PhD for students entering with Bachelor's Degree (without MS degree) - 36 Credit Hours of 600/700-level Courses

Total Minimum Hours Required for PhD for students entering with MS degree - 12 Credit Hours of 700-level Courses

I. For Students Entering Without a MS Degree

Code	Title	Credits
Required Courses		
Students must take the following five core courses and maintain a 3.0 GPA or higher:		15
EVSC 610	Environmental Chemical Science	
EVSC 612	Environmental Analysis	
EVSC 616	Toxicology	
EVSC 627	Environmental Microbiology	
EM 631	Legal Aspects in Environmental Engineering	
Elective Courses		**21**
Students are required to take a minimum of seven 600- or 700-level courses (21 credit hours) with at least four (12 credit hours) of these at the 700-level. Courses are to be chosen from the departmental offerings or from outside of the department as deemed necessary. Up to six credit hours of Independent Study courses may be earned in fulfillment of the elective courses requirements.		
EVSC 622	Bioremediation	
EVSC 613	Environmental Problem Solving	
EVSC 614	Quantitative Environmental Risk Assessment	
EVSC 615	Global Environmental Problems	
EVSC 702	Special Topics in Environmental Science II	
EVSC 711	Advanced Environmental Analysis	
EVSC 712	Hazardous Substance Management	
EVSC 715	Energy and Sustainability	
EVSC 725	Independent Study I	
EVSC 726	Independent Study II	
ENE 630	Physical Processes of Env Syst	
ENE 660	Introduction to Solid and Hazardous Waste Problems	
ENE 661	Environmental Microbiology	
ENE 662	Site Remediation	
ENE 663	Water Chemistry	
ENE 664	Physical and Chemical Treatment	
ENE 665	Biological Treatment	
ENE 672	Stormwater Management	
ENE 673	Sustainability and Life Cycle Analysis	
IE 615	Industrial Hygiene and Occupational Health	
EPS 612	Introduction to Environmental Policy Studies	
EPS 614	Environmental Economics and Management	
EPS 622	Sustainable Politics and Policy	
EPS 638	Physical Geography	
CHEM 714	Pharmaceutical Analysis	
CHEM 748	Nanomaterials	
CHEM 764	Advanced Analytical Chemistry	
CHE 681	Polymerization-Principles and Practice	
CHE 724	Sustainable Energy	
MTSE 719	Physical Principles of Characterization of Solids	
Total Credits		36

Dissertation Research Credits

EVSC 792B Pre-Doctoral Research (after completing qualifying exam requirements)
EVSC 790 Doctoral Dissertation (after completing research proposal requirements)

Qualifying Examination

By the end of the second year, students must pass the PhD qualifying oral examination. A student is given two chances to clear the exam. The qualifying examination consists of writing and orally defending an original research proposal to the student’s dissertation committee in which the committee conducts an oral exam of the candidate (majority vote of the committee required). The original research proposal will focus on a topic not directly related to the student's dissertation research and must be approved by the dissertation committee prior to development of the proposal. Failure to pass the PhD qualifying exam will result in dismissal from the program.

Dissertation Research Proposal

By the end of the first year of passing the qualifying exam (excluding summers), students must successfully present a proposal of their dissertation research to their dissertation committee and gain approval by a majority vote of the committee.

Dissertation Defense

The final requirement for the PhD degree is completion of a satisfactory written dissertation of the student's research, along with successful presentation and defense of the dissertation to the student's dissertation committee (majority vote of the committee).

II. For Students Entering With a MS Degree

Students with a recognized MS degree in environmental, chemical and biological sciences or closely related field such as engineering may, with approval of the PhD Graduate Committee be admitted to pursue the PhD degree in Environmental Science and be required to earn a minimum of 12 credit hours of coursework at the 700-level. Students entering the program without a MS in Environmental Science are required to take the core courses outlined in I along with the 700 level credits. Students with a MS in Environmental Science will be waived core requirements if they have taken similar courses before, and will complete only those among the core that they have not completed before.

Code	Title	Credits
Elective Courses		**12**
Students are required to take a minimum of four 700-level courses (12 credit hours). Courses are to be chosen from the departmental offerings while up to three credit hours may be selected from outside of the department.		
EVSC 702	Special Topics in Environmental Science II	
EVSC 711	Advanced Environmental Analysis	
EVSC 712	Hazardous Substance Management	
EVSC 715	Energy and Sustainability	
EVSC 725	Independent Study I	
EVSC 726	Independent Study II	
CHEM 714	Pharmaceutical Analysis	
CHEM 748	Nanomaterials	
CHEM 764	Advanced Analytical Chemistry	
CHEM 777	Principles Pharm Chemistry	
CHE 724	Sustainable Energy	
MTSE 719	Physical Principles of Characterization of Solids	
Total Credits		12

Dissertation Research Credits

EVSC 792B Pre-Doctoral Research (after completing qualifying exam requirements)
EVSC 790 Doctoral Dissertation (after completing research proposal requirements)

Qualifying Examination

By the end of the second year, students must pass the PhD qualifying oral examination. A student is given two chances to clear the exam. The qualifying examination consists of writing and orally defending an original research proposal to the student's dissertation committee in which the committee conducts an oral exam of the candidate (majority vote of the committee). The original research proposal will focus on a topic not directly related to the student's dissertation research and must be approved by the adviser and advisory committee prior to development of the proposal. Failure to pass the PhD proficiency exam will result in dismissal from the program.

Dissertation Research Proposal

Within a year of passing the qualifying exam, students must successfully present a proposal of their dissertation research to their dissertation committee and gain approval by a majority vote of the committee.

Dissertation Defense

The final requirement for the PhD degree is completion of a satisfactory written dissertation of the student's research, along with successful presentation and defense of the dissertation to the student's dissertation committee (majority vote of the committee).

Grades

All students must maintain a grade point average of at least 3.0.

History

The Federated History Department of NJIT and Rutgers-Newark offers the Master of Arts in History for generalists and for students interested in preparing for further graduate study in history, and the Master of Arts in Teaching for current and prospective secondary school teachers of history and social studies. The objective of the graduate history program is to furnish a broad yet rigorous course of study in preparation for careers in teaching, business, law, government, administration, and other fields related to history, as well as to enhance the professional experience and increase the opportunities for advancement of students who are already working as professionals in these fields.

Program administration and teaching are shared by faculty from both campuses, and the full resources of both universities are available to all history graduate students and faculty. Resources include access to the Rutgers University library system of more than three million volumes, to the outstanding collection in the history of medicine at UMDNJ, and to excellent history collections in the region. The program emphasizes hands-on learning and archival research in association with local institutions, such as the Thomas Edison National Historic Site in nearby West Orange and the Newark Museum and the New Jersey Historical Society in Newark.

The joint Rutgers-Newark/NJIT graduate history program is the largest and most diverse master's-level history program in New Jersey. Many of the graduate faculty have national or international reputations as scholars, representing a wide variety of time periods and fields of study. The program is particularly noted for its strengths in environmental history and the history of science, technology and medicine; the history of communication, cultural and intellectual history; diplomatic history; history of women; pre-Civil War and contemporary America; African and African-American history; legal history; and global and comparative history.

Master of Arts in History

The M.A. in History furnishes a broad yet rigorous training in history in preparation for a wide variety of careers in education, law, business, medicine, and administration.

Admission Requirements

Applicants must have an undergraduate degree from an accredited institution and favorable letters of recommendation from professors familiar with their work. An undergraduate GPA of at least 3.0 is normally required. Students must provide GRE scores.

Application

Students interested in the program should contact the NJIT history graduate coordinator (http://directory.njit.edu/PersDetails.aspx?persid=maher), and apply to Rutgers-Newark (https://sasn.rutgers.edu/academics-admissions/academic-departments/federated-department-history/graduate-programs-history/).

Major Fields

American History

See the Federated History Department **(**http://history.njit.edu/academics/graduate/ma-history.php#american**)** website for more information.

World History

See the **Federated History Department** website for more information.

History of Technology, Environment, and Medicine/Health

Based at NJIT, this concentration is a unique integration of three relatively new and increasingly important historical sub-disciplines. Students concentrating in the History of Technology, Environment, and Medicine/Health explore not only the interrelationships between environmental transformations, technology in society, and health and medicine, but also their social meanings, their cultural relations, their political, social, and gender histories, and their local, national, and global contexts. NJIT has a distinguished concentration of faculty in these areas, with particular strengths in American environmental and urban environmental history; the social and cultural history of medicine; and the history of technology and communication.

Students interested in pursuing this major field of concentration should contact the NJIT history graduate coordinator (http://directory.njit.edu/PersDetails.aspx?persid=maher). Additional information on the History of Technology, Environment, and Medicine/Health concentrations can also be found here (http://history.njit.edu/academics/graduate/ma-history.php#american).

Master of Arts in Teaching (History)

The Master of Arts in Teaching is a terminal degree for students who are preparing for, or are already engaged in, careers in secondary school teaching in history and social studies. See the Federated History Department (http://history.njit.edu/academics/graduate/mat-history.php) website and the **Rutgers Graduate School-Newark** catalog for more information.

NJIT History Faculty

C

Çelik, Zeynep, Distinguished Professor (NJIT College of Architecture and Design)

D

Dent, Rosanna, Assistant Professor

E

Elektra Kostopoulou, University Lecturer .

H

Hamilton, Louis, Professor

L

Lefkovitz, Alison L., Associate Professor

M

Maher, Neil M., Professor

P

Pemberton, Stephen, Associate Professor

R

Riismandel, Kyle, Senior University Lecturer

S

Schweizer, Karl W., Professor

Rutgers-Newark History Faculty

A

Amzi-Erdogdular, Leyla, Assistant Professor

Asen, Daniel, Assistant Professor

C

Caplan, Karen, Associate Professor

Chang, Kornel, Associate Professor

Cooper, Melissa, Assistant Professor

Cowans, Jon, Associate Professor

D

Diner, Steven J., University Professor

E

Esquilin, Marta, Assistant Professor

F

Farney, Gary D., Associate Professor

Feldstein, Ruth, Professor

G

Giloi, Eva, Associate Professor

Goodman, James, Distinguished Professor

H

Habtamu Tegegne is Assistant Professor

K

Krasovic, Mark, Associate Professor

M

Monteiro, Lyra D., Assistant Professor

Murphy, Brian Phillips, Associate Professor

Mayte Green-Mercado, Assistant Professor

R

Rizzo, Mary, Assistant Professor

S

Satter, Beryl, Professor

Stewart-Winter, Timothy, Associate Professor

Strub, Whitney, Associate Professor

T

Habtamu Tegegne, Assistant Professor

Truschke, Audrey, Assistant Professor

V

Varlik, Nükhet, Associate Professor

- History - M.A. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/history/ms/)

History Courses

HIST 600. History Reseach Seminar. 3 credits, 3 contact hours.
This seminar course introduces students to various methods for conducting historical research using primary and secondary source materials, and teaches them how to write a formal research paper. The seminars are on a particular topic chosen by the professor, and can focus on a chronological period or geographic region, on an historical event, cultural movement, or social group, or on a type of history such as environmental history, the history of technology, or the history of health and medicine.

HIST 620. City and Disease in History. 3 credits, 3 contact hours.
Explores the dynamic interaction between the growth of cities and changes in the experience and location of disease. Presumes the intertwining of these two historical developments in the birth of a distinctly urban identity, one predicated on the notion that the modern city is somehow inherently diseased. Focuses on the New York and Newark metropolitan areas in the nineteenth and twentieth centuries. Among the topics considered are epidemic outbreaks, quarantines, the technology and organization of sanitation and hygiene, the professional formation of public, industrial and occupational medicine, and medical and popular responses to immigration.

HIST 622. Culture and Science in the History of American Medicine. 3 credits, 3 contact hours.
Provides an overview of American medical history and a familiarity with the theoretical and practical ramifications of different approaches to the complex relationships between medicine, science, and culture. Topics include: the extent to which medicine is or has been scientific; reasons why science has been considered so important to medicine's professional culture; and the degree to which medicine's professional culture has been shaped by science as well as other factors, such as economic and political self-interest, technology, class, race, gender, and other kinds of cultural values.

HIST 624. Technology, Environment and Medicine in World History, 1500-1900. 3 credits, 3 contact hours.
Examines the interrelationship between the emerging modern world system and changes in technology, environment, and medicine, with particular emphasis on European overseas expansion and its impact in non-Western regions.

HIST 626. Social History of American Medicine Since 1800. 3 credits, 3 contact hours.
Topics include the practices of 19th-century regular medicine; the relation between medical concepts and mainstream social thought; the treatment of women's health; antebellum alternative healers and alternative politics; the triumphs of late 19th- and early 20th-century medical therapeutics; the emergence of medicine as big business; medicine and racism; the emergence of nursing as a profession; modern medicine in an international perspective; New Age healing; the AIDS crisis and AIDS activism; and contemporary debates on the future of health care in the United States.

HIST 628. Gender, Science and Technology in the Modern World. 3 credits, 3 contact hours.
Introduction to a wide range of political and cultural analyses of science and technology, with an emphasis on recent feminist critiques of science. Explores the questions of scientific neutrality; the gendering of scientific knowledge; the relationship between science, technology, and capitalism; the role of science in international politics; and why science has not freed women.

HIST 630. History of the Body in Modern Western Culture. 3 credits, 3 contact hours.
Considers medical or scientific history primarily in terms of implications for bodily experience in everyday life. Begins with grand narratives of historical shifts in bodily perceptions and practices, and proceeds to more focused narratives of changing bodily experience, engaging key distinctions between genders, classes, and species as well as perceptions of pain and internal bodily structure. Materials will be drawn from early modern and modern Europe, as well as more recent bodily experience in the United States.

HIST 632. Global Hist of Tech & Culture. 3 credits, 3 contact hours.
Treats the relationship between technology and cultural values in a variety of historical and geographical settings, from early modern Japan to twentieth-century America. Examines the ways in which cultural ideals, conceptions, and preconceptions serve to influence the rate and manner of technological change, as well as the ways in which technology affects social and cultural life.

HIST 634. Environmental History of North America. 3 credits, 3 contact hours.
Explores the dialogue between humankind and the environment in North America over the course of the last four centuries. Examines the latest and most interesting work done in the new field of environmental history to see what such a perspective has to offer.

HIST 635. History of Technology, Environment and Medicine: Theory and Method. 3 credits, 3 contact hours.
A team-taught course which surveys the methods employed in the three fields. Explores the interdisciplinary nature of each field, and the value of interdisciplinary scholarship.

HIST 637. Global Environmental History. 3 credits, 3 contact hours.
This course takes a global view of human interaction with the natural world, mixing broad themes such as colonialism and industrialization with detailed case studies in an effort ot understand the ways that people and the environment have mutually shaped one another. Because environmental change often transcends national boundaries, this course places important subjects in environmental history such as disease, agriculture, pollution, and environmentalism into a global and transnational context.

HIST 638. Social History of Communication. 3 credits, 3 contact hours.
Treats selected themes in the history of communication in different social and cultural contexts, from the ancient world to the twentieth century. Topics include: orality, proto-literacy, and literacy in ancient and medieval cultures; printing and the development of print culture in the early modern world; the ?communication revolution? of the late 19th and early 20th centuries; and historiographical debates over the role of communication technologies in society.

HIST 640. The Urban Environment. 3 credits, 0 contact hours.
Examines the role of the economy, culture, and technology in shaping the urban environment. Makes extensive use of Newark and the New York metropolitan area, including field observations and local research. In addition to other topics, explores in detail spatial relationships, the role of transportation, and the development of suburbia.

HIST 642. The History of Health and International Development. 3 credits, 3 contact hours.
This course examines the history of western efforts to promote health and nutrition in the 'developing world" from the beginnings of tropical medicine. We will trace this history through its many permutations from the establishment of colonial health services to the development of the Global Programme on AIDS. In doing so, we will explore the various economic and political interests and underlying cultural assumptions that have shaped the development of ideas and practices associated with international health and development.

HIST 644. War, Technology and Society, 1500-1914. 3 credits, 3 contact hours.
Examines key themes in the interrelationship between warfare, technology and society from the beginnings of modern warfare until World War I. Primary emphasis placed on the historical connections between violent conflict, the technical means by which it is carried out, and the socio-political environment within which wars take place. The effect of technology upon war and considerations of the effect of war on technological change and development. Samples the rich tradition of thought and ideas produced by philosophers and theorists on these themes.

HIST 645. American Legal History to 1860. 3 credits, 3 contact hours.
Readings and discussion on the legacy of common law after the Revolution; the emergence of legal instrumentalism; and the evolution of tort, contract, and damages in the context of industrialism and economic growth.

HIST 650. History of American Conservatism. 3 credits, 3 contact hours.
This course examines postwar American conservatism through classic works and contemporary studies. Topics include the rise of conservatism, groups under the conservative umbrella, and the rise of the right as related to key events in postwar history (Cold War, McCarthysim, the '60s, the suburbs and urban change). Course interrogates postwar conservatism with respect to American political and intellectual history and in relation to histories of gender, race, class, sexuality, place and religion.

HIST 652. Topics in the History of Technology. 3 credits, 3 contact hours.
Selected topics in the history of technology.

HIST 653. Topics in European Intellectual and Cultural History. 3 credits, 3 contact hours.
Examination of issues and methods in European intellectual and cultural history, with a consideration of some leading problems in the field.

HIST 654. Topics in American Intellectual and Cultural History. 3 credits, 3 contact hours.
Examination of issues and methods in American intellectual and cultural history, with a consideration of some leading problems in the field.

HIST 655. Topics in American Urban and Ethnic History. 3 credits, 3 contact hours.
Examination of issues and methods in American urban and ethnic history, with a consideration of some leading problems in the field.

HIST 656. Topics in the History of Health. 3 credits, 3 contact hours.
Selected topics in the history of Health.

HIST 657. Topics in Environmental History. 3 credits, 3 contact hours.
Selected topics in environmental history.

HIST 658. Topics in American Legal History. 3 credits, 3 contact hours.
Readings and discussion on the growth of legal formalism, the evolution of substantive due process, changes in legal education and the legal profession, and the evolution of private law.

HIST 660. The Enlightenment in Britain. 3 credits, 3 contact hours.
The 18th century was the age of the Enlightenment. Great Britain became a unified polity and the most powerful imperial force in the world. We examine the Enlightenment in Britain against the backdrop of war and empire, imperial consumer culture, the growth and significance of sociability and politeness, representations of gender, the writing of cultural history, social uses of science/technology, print culture, and competition among varying notions of ethnic identity.

HIST 661. Problems and Readings in European History since 1850. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in European history since 1850.

HIST 662. Prob. and Read: Hist/US Foreighn Policy and Diplomacy. 3 credits, 3 contact hours.
Examination of issues and methods in American diplomatic history, with a consideration of some leading problems in the field.

HIST 663. Problems and Readings in American History, 1492-1789. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history rom 1492 to 1789.

HIST 664. Problems and Readings in American History, 1789-1865. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history from 1789 to 1865.

HIST 665. Problems and Readings in American History, 1865-1914. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history from 1865 to 1914.

HIST 666. Problems and Readings in American History, 1890-1945. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literatue in American history from 1890 to 1945.

HIST 667. Problems and Readings in American History, 1945-Present. 3 credits, 3 contact hours.
Introduction to the major historiographical problems and recent literature in American history since 1945.

HIST 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

HIST 701B. Master'S Thesis. 3 credits, 3 contact hours.
Restriction: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

HIST 701C. Master'S Thesis. 6 credits, 6 contact hours.
Restriction: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

HIST 702. Master's Essay. 3 credits, 3 contact hours.
For those who don't write a 6 credit thesis, the 3 credit Master's Essay caps the M.A./M.A.T. A substantial work done with an advisor, may be: 1. Interpretive historical essay based on primary source research. 2. Narrative history based on primary source research. Prereq: R510:504, R510:505, or R510:506. 3. Historiographical essay. 4. Content-focused curriculum design, either a course or significant portion thereof. 5. Design for an historical museum exhibition/other work in public history. Prereq: R510:565.

HIST 725. Independent Study. 3 credits, 1 contact hour.
Restriction: permission of graduate history advisor and course instructor.

HIST 726. Independent Study. 3 credits, 1 contact hour.
Restriction: permission of graduate history advisor and course instructor.

HIST 727. Independent Study. 3 credits, 3 contact hours.
Restriction: permission of graduate history advisor and course instructor.

HIST 791. Seminar in History of Technology, Environment and Medicine. 0 credits, 0 contact hours.
Faculty, students and invited speakers present and discuss current topics of research in history, technology and medicine.

Rutgers-Newark Courses

R510 505. History, Fiction And Fact. 3 credits, 3 contact hours.

R510 506. Poetics Of History. 3 credits, 3 contact hours.

R510 515. Hist Of Gender. 3 credits, 0 contact hours.

R510 520. Topics/History. 3 credits, 3 contact hours.

R510 525. Colloq History Of Women. 3 credits, 0 contact hours.

R510 526. Rdngs Afro-Amer History. 3 credits, 0 contact hours.

R510 527. European Diplomatic Hist. 3 credits, 3 contact hours.

R510 528. Eur Polit & Diplom Hist. 3 credits, 0 contact hours.

R510 529. ST:Eur Intell&Cult Hist. 3 credits, 3 contact hours.

R510 531. Amer Diplomatic Hist. 3 credits, 0 contact hours.

R510 532. American Diplomatic History. 3 credits, 3 contact hours.

R510 533. Topics In Envir Hist. 3 credits, 3 contact hours.

R510 537. Problems Ancient World. 3 credits, 3 contact hours.

R510 538. Problems Ancient World. 3 credits, 3 contact hours.

R510 539. Probs Medieval History. 3 credits, 0 contact hours.

R510 543. European Hist 1650. 3 credits, 3 contact hours.

R510 547. Comparative Colonial History. 3 credits, 3 contact hours.

R510 548. Amer Environmntl History. 3 credits, 3 contact hours.

R510 549. Mod Latin Am History. 3 credits, 3 contact hours.

R510 551. Amer Intellect & Culture Hist. 3 credits, 3 contact hours.

R510 552. Topics-Amer Intell Cult Hist. 3 credits, 3 contact hours.

R510 553. Amer Polit & Legal Hist. 3 credits, 0 contact hours.

R510 555. Am Urban & Ethnic History. 3 credits, 3 contact hours.

R510 563. Heredity, Health And Disease. 3 credits, 3 contact hours.

R510 564. History of Urban Education. 3 credits, 3 contact hours.

R510 565. Public History. 3 credits, 3 contact hours.

R510 566. Writing American History. 3 credits, 3 contact hours.

R510 567. Global Environ. 3 credits, 3 contact hours.

R510 571. Historical & Social Theory. 3 credits, 3 contact hours.

R510 576. American Hist, 1492-1789. 3 credits, 0 contact hours.

R510 577. Prob Am Hist 1789-1865. 3 credits, 0 contact hours.

R510 581. Amer History 1865-1914. 3 credits, 0 contact hours.

R510 583. American History 1912 To 1945. 3 credits, 0 contact hours.

R510 585. Prob & Rdngs Amer Hist. 3 credits, 0 contact hours.

R510 589. Prob & Rdng African Hist. 3 credits, 0 contact hours.

R510 590. Prob & Read African Hist. 3 credits, 0 contact hours.

R510 593. Cult & Sc Hist Am Med. 3 credits, 3 contact hours.

R510 595. Soc Hist, Am Med-1800. 3 credits, 3 contact hours.

R510 598. Hist-Tech, Env & Med. 3 credits, 3 contact hours.

R510 599. Social History-Communic. 3 credits, 3 contact hours.

R510 618. Sem Teaching History. 3 credits, 3 contact hours.

R510 619. Intership In Public History. 3 credits, 3 contact hours.

R510 632. Technology Culture & History. 3 credits, 3 contact hours.

R510 678. Advanced Topics In Hist. 3 credits, 3 contact hours.

R510 695. Independent Study In History. 3 credits, 3 contact hours.

R510 696. Adv Ind Study Hist. 3 credits, 3 contact hours.

R510 697. Adv Research. 3 credits, 3 contact hours.

M.A. in History

Degree Requirements

A minimum of 30 credits is required, including 18 in a major field and 6 in courses outside of the major field chosen in consultation with a faculty advisor. The remaining 6 credits may be completed through a Master's Thesis or a combination of a Master's Essay and an additional course.

Major Field

The M.A. program in history offers a choice of three major fields in areas that are particularly well supported by the research and teaching interests of the history faculty:

- American History (https://history.njit.edu/academics/graduate/ma-history.php#american)
- World History (https://history.njit.edu/academics/graduate/ma-history.php#world)
- History of Technology, Environment and Medicine/Health (https://history.njit.edu/academics/graduate/ma-history.php#technology)

To ensure a program of reasonable depth and coherence, each student takes at least 18 credits of course work in one of these major fields, chosen in consultation with the Graduate History Director or designated advisor.

Courses Outside the Major Field

To add breadth and diversity to the program of study, each M.A. candidate must take at least two courses (6 credits) outside of the chosen major field, often selected from among the two major fields in which a student does not have a primary concentration (e.g., a student with a major field in American History may elect a minor field in World History or in History of Technology, Environment and Medicine/Health). It is preferable that both courses be in the same field, but this is not required.

Master's Thesis

Students pursuing the Thesis Option earn 6 credits for the thesis, which should be a sustained work of scholarship written under the supervision of a qualified faculty advisor. The thesis will normally be on a topic within a student's major field. It must be based on primary source research.

Master's Essay

Students who do not elect to write a thesis must write a 3 credit Master's Essay. The Master's Essay is a substantial piece of written work, the capstone of the M.A./M.A.T. program for those students who elect not to write a 6-credit Master's Thesis. The essay is undertaken in consultation with an advisor, and may take one of several forms:

1. An interpretive historical essay based on research in primary sources, in form much like the M.A. thesis, but shorter.
2. A short work of narrative history, emphasizing form as well as content of the writing, also based on research in primary sources. (prerequisite: 26:510:504 Reading and Writing Narrative History, or 26:510:505 History in Fiction and Fact, or 26:510:506 The Poetics of History)
3. A historiographical essay, reviewing the literature on a particular problem in, or aspect of, history.
4. A design for a new curriculum, either a course or a significant portion of a course, with the focus on content more than on pedagogy.
5. A design for an exhibition in a historical museum or another appropriate work in public history. (prerequisite: 26:510:565 Public History)

M.A. in History (Master's thesis option)

Code	Title	Credits
Major Field Courses		
600 Level Courses in Major Field		18
Courses Outside the Major Field		
Two 600 or 700 level courses outside of the major field		6
Thesis		
HIST 701C	Master'S Thesis	6
Total Credits		30

M.A. in History (Master's essay option)

Code	Title	Credits
Major Field Courses		
600 Level Courses in Major Field		18
Courses Outside the Major Field		
Two 600 or 700 level courses outside of the major field		6

Essay		
Elective Courses		
One 600 or 700 level course		3
HIST 702	Master's Essay	3
Total Credits		30

Humanities

This program is designed to prepare students for careers in the field of technical communication. Students learn to approach communication issues in a scholarly and professional manner, developing abilities in critical thinking, problem solving, and navigating effectively and ethically through our scientific and technological society.

The program is intended for students and communication professionals who want to develop abilities in

- Social media
- User-centered design
- Usability testing and knowledge management
- Advanced communication theory and research methods
- Technical editing
- Writing and speaking in teams, in a wide range of professional environments

Masters of Science in Professional and Technical Communication

Please see our web site https://humanities.njit.edu/ms-professional-and-technical-communication (https://humanities.njit.edu/ms-professional-and-technical-communication/) for updated information.

The Master of Science in Professional and Technical Communication (MSPTC) prepares students for careers in the rapidly growing field of technical communication. This degree enables students to acquire an understanding of information technologies and to approach communication issues with new problem-solving skills. Familiarity and technical proficiency with many different media tools and services will also be gained. Professional experts will provide strong theoretical foundations within a practical framework. The MSPTC is entirely and only available online (in distance learning format).

Admission Requirements

Students must have an undergraduate degree in any field with strong interest in science and technology and/or communication and media and must submit the following.

- a statement outlining how the degree will meet personal and professional objectives;
- a current resume;
- one letter of recommendation;
- a portfolio of work (Three samples of writing, web development, CD-ROM, or other appropriate media that demonstrate abilities for clear expression);
- Graduate admission application;
- Official transcripts of all prior work and certificate of graduation;
- GRE scores (These scores are required of all international applicants, all applicants who have earned their last degree outside of the United States, and students who wish to apply for merit-based financial support on individual basis; other applicants do not need GRE scores);
- TOEFL scores of 550 (pencil and paper) or 79 (IBT) are required of all international applicants.

Graduate Certificate Programs: Two 12-credit graduate certificates are available as a step toward this degree

- Technical Communication Essentials
- Social Media Essentials

Please see **Graduate Certificates** for further information. For more information about continuing and distance education, please contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; e-mail: cpe@njit.edu.

NJIT Faculty

A

Ascarelli, Miriam F., University Lecturer

B

Bodner, Janet, Associate Director

C

Castronova, Louise, Senior University Lecturer

Cohen, Maurie, Professor

Curley, Jonathan R., Senior University Lecturer

E

Edel, Gareth

Egan, John A., University Lecturer

Esche, John N., University Lecturer

Estrada, Daniel J., University Lecturer

F

Fleischer, Doris Z., Senior University Lecturer

Funkhouser, Christopher T., Professor

G

Gorelick, Risa, University Lecturer

H

Henry, Rolanne, Senior University Lecturer

Holbrook, J. Britt, Assistant Professor

Hunt, Theresa A., University Lecturer

J

Johnson, Carol S., Associate Professor

K

Katz, Eric, Professor and Chair

Kerley, Michael, Associate Director

Khichi, Narendra-Neel, University Lecturer

Kimmelman, Burt J., Professor

Klobucar, Philip Andrew, Associate Professor

Kmiec, David M., University Lecturer

L

Lipuma, James M., Senior University Lecturer

Longo, Bernadette C., Associate Professor

M

McRae, Calista A. Assistant Professor

O

O'Neill, Megan E., Assistant Professor

O'Sullivan, William, University Lecturer

P

Pardi, Nina L., Senior University Lecturer

Paris, Jerome, Director

R

Rittenhouse, Michele R., Director

Rothenberg, David B., Distinguished Professor

Rutkoff, Rebekah, Assistant Professor

S

Siemann, Catherine A., University Lecturer

Steffen, Nancy L., Associate Professor

W

Waltz-Cummings, Anika E., University Lecturer

Wells, Louis A., University Lecturer

- Professional and Technical Communication - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Programs

- Applied Science (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/applied-science-cert/)
- Digital Marketing Design Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/digital-marketing-design-essentials-cert/)
- Instructional Design, Evaluation and Assessment (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/instructional-design-evaluation-assessment-cert/)
- Social Media Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/social-media-essentials-cert/)
- Technical Communication Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/technical-communication-essentials-cert/)
- User Experience Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/user-experience-essentials-cert/)

Humanities Courses

PTC 601. Advanced Professional and Technical Communication. 3 credits, 3 contact hours.
Provides the foundation and direction for all Professional and Technical Communication coursework. This course introduces students to the profession and the academic discipline of technical/professional communication. Modules include usability analysis; visual information; ethics; global diversity, global communication; report writing; information literacy; communicating with new technologies; and technical writing style. Students begin development of the MSPTC ePortfolio.

PTC 603. Identity, Technology, and Communication. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601. Examines the complex ways in which technology constructs and is constructed by society, with emphasis on interrelationships between technology and communication. Discussions focus on how technological change is expressed in social and political movements, literature, art, architecture, and philosophy and how they, in turn, influence the future direction of technology. Design and updating of the MSPTC ePortfolio will be required in this seminar.

PTC 604. Communication Theory and Research. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601Reviews the major theories of communication and provides strategies for research in the field of Professional and Technical Communication. The course focuses on these research methods: problem statement and hypothesis formulation derived from theory; research design and data generation; existing information sources and their acquisition; and analytic techniques. Students develop analytic methods necessary to create a well-considered thesis proposal. Design and updating of the MSPTC ePortfolio will be required in this seminar.

PTC 605. Elements of Visual Design. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601. Provides an understanding of and competency in the visual presentation of information. Course integrates theories of design, techniques of composition, and technologies of electronic and print publishing. Modules include both design principles and hands-on practice in visual literacy, layout and design, and graphic tools. Design and updating of the MSPTC ePortfolio will be required in this seminar.

PTC 606. Advanced Information Design. 3 credits, 3 contact hours.
Develops online visual communication strategies and community building. The course will cover the design and creation of multimedia objects, usability heuristics, navigation theory, contemporary design practices and online community building. Students will be required to create media-rich multidimensional online projects that encourage and facilitate interaction and team-building in the online environment. Design and updating of the MSPTC ePortfolio will be required for this seminar.

PTC 610. Research Methods for Information Design. 3 credits, 3 contact hours.
Introduces user research methods such as contextual inquiry, ethnographic field studies, card sorting, affinity diagramming, and usability testing that provide the foundation for user- centered interaction design.

PTC 612. Theory and Practice of Text Encoding. 3 credits, 3 contact hours.
Students will learn to identify considerations and methods for efficient text encoding. Topics covered will include text encoding tools, markup languages, document analysis, and workflow design for text delivery. After taking this class, students should be able to analyze processes and technologyies that support the collection, management, and publishing of content in a variety of forms and media.

PTC 620. Proposal Writing. 3 credits, 3 contact hours.
Provides an understanding of and practice in proposal writing for corporations, foundations, and government agencies. Students build skills to create a range of persuasive documents including proposals for research grants, responses to requests for proposal, and government proposals.

PTC 622. Working in Teams: Collaborative and Interpersonal Communications. 3 credits, 3 contact hours.
Introduces interpersonal and collaborative communication topics relating to face-to-face and virtual teams. Covers communication and documentation functions in agile project environments. Examines mobile workplace communication strategies.

PTC 624. Professional and Technical Editing. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601 . Presents the theory and practice of editing professional and technical writing. Topics include correctness and conciseness, hard copy and on-line editing, editing graphics, document management, editor-author relationships, and ethical considerations in editing. Students edit writing samples from a variety of technical fields.

PTC 626. Communication Media Design Studio. 3 credits, 3 contact hours.
This course integrates language and media in a studio approach to multimodal communication projects. Students work with instructor to design individual projects using current media applications.

PTC 628. Analyzing Social Networks. 3 credits, 3 contact hours.
Prerequisite: PTC 601 for MSPTC students; approval of instructor for non-MSPTC students. This course will provide students with an overview of social networks by introducing them to the unique terminology of social networks (centrality, boundary spanners, directional ties, etc.) Positive and negative characteristics of social networks will be discussed, followed by visualizations and analyses of those characteristics. Students will read selected journal articles explaining how social networks relate to communication and the flow of information within organizations. The culmination of the course will be a project in which students will create and analyze their own social network, most likely drawing their data from the popular social media site Facebook and using ORA, a freeware social network analysis application created by Carnegie Mellon University.

PTC 629. Theory and Practice of Social Media. 3 credits, 3 contact hours.
Introduces social media strategies for reading and writing in today's multi-cultural, screen-oriented, networked culture. Students study relationship between mediated communication and human community and gain hands-on experience with chatting, blogging, tagging, wiki writing, tweeting and social media presentation. Students strategize, plan, design and produce social media projects of their own.

PTC 631. Communication and Environmental Problem Solving. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601. Develops critical thinking on ecological issues for problem solving by integrating technical information, human values, and communication with environmental change. Students combine theory, research and models, case studies, visual thinking, and scientific inquiry for application in individual decision-making course project.

PTC 632. Content Management and Information Architecture. 3 credits, 3 contact hours.
Prerequisite or Corequisite: PTC 601. Today's complex systems often produce complex information needs that require new technical communication methods and tools. This course will focus on the use of Information Architecture methodologies (such as, DITA or DocBook) to develop a structure for presenting technical information and on Content Management tools for creating a single source repository for this information. Students will also use theory and practical applications to design and develop a structured online Help module.

PTC 640. Health Communications. 3 credits, 3 contact hours.
This course will focus on the use of communication strategies to inform and influence individual and community decisions regarding health. The course will cover: the multidimensional nature of health communication, research in health communication, behavioral theories in health communication, rhetorical theories in health communication, legal and ethical concerns in health communication, the communication of risk and uncertainty, and the design of health campaigns. Students will be required to (a) research and prepare a health communication strategy for use in a specific context and (b) to design an accompanying print or hypertext document to be used in that context.

PTC 642. Corporate Media and Communication. 3 credits, 3 contact hours.
Introduces the dymanics of communication within complex organizations. Develops communication skills for contemporary global corporate and business markets. Focuses on the efforts of businesses and organizations to communicate and persuade in target audiences. Covers translation issues in developing corporate media.

PTC 644. Communication in Technology Transfer and Innovation. 3 credits, 0 contact hours.
Examine roles of communication in innovation development and technolgy transfer. Students review models of communication in technology transfer in global contexts. Issues such as audience analysis, user experience, participatory design, and knowledge transfer will be investigated.

PTC 650. eLearning Design for Mobile. 3 credits, 3 contact hours.
Designing eLearning for mobile platforms is a critical skill for today's technical communicator. Specific skills and tools are required to ensure a successful implementation. Based on proven user centered design concepts, this course provides the student with the skills necessary to create effective mobile training programs.

PTC 672. Design Instruction Assess Meth. 3 credits, 3 contact hours.
Prerequisite: Students must have a graduate standing and should be enrolled in MSPTC program or the Instructional Design and Educational Assessment certificate. Student must meet these requirements, approval of instructor is required. Examines planning and implementation of instruction to facilitate learning and analysis of methods of data gathering on learner progress and mastery, lessons and learning objects so appropriate instructional strategies with associated methods of formative and summative assessments that can yield data for learner assessment and course evaluation can be selected or develop to suit the instructional style, learner needs, and instructional situations.

PTC 681. Tech in Class & Learning Envir. 3 credits, 3 contact hours.
Prerequisite: Students must have a graduate standing and should be enrolled in MSPTC program or the Instructional Design and Educational Assessment certificate. Student must meet these requirements, approval of instructor is required. This course examines the various types of technology necessary to develop, use, and process the results of assessments as well as facilitate and augment instructional design. This course examines the integration of present and likely future technology into instruction to foster community, collaboration, conceptual development, and exceptional academic performance as well as a more effective and well-understood assessment system.

PTC 691. ePortfolio Capstone Seminar. 0 credits, 0 contact hours.
This course is taken in the student's final semester before graduation. Students complete final revisions of the ePortfolio of work completed in MSPTC seminars (may also include professional and service projects). Student ePortfolios must successfully demonstrate MSPTC core competencies and be presented in an oral presentaiton for faculty and other students.

PTC 698. Selected Topics in Professional and Technical Communication. 3 credits, 3 contact hours.
Prerequisite or corequisite: PTC 601 This is a Special Topics course (does not require CGE approval). It was presented to CGE in an effort to attract more students. Students will learn approaches to understanding and producing the forms of writing central to academic research. They will review literature, peer-review the work of others, prepare conference material, and produce a submission-quality journal or conference paper in their field of study. The current plan is to run the course every Spring.

PTC 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisites: Approval of graduate advisor, and completion of core courses. Requires demonstration of student's ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. Based on experiential research (internship, co-op, work experience) student submits a proposal, develops a project (e.g., guidebook, manual, online documentation, website, video, podcast) and completes a paper describing the theory and methodology supporting the project application. Submission of the MSPTC ePortfolio demonstrating proficiency is required for graduation.

PTC 700B. Master'S Project. 3 credits, 3 contact hours.
Prerequisites: Approval of graduate advisor, and completion of core courses. Requires demonstration of student's ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. Based on experiential research (internship, co-op, work experience) student submits a proposal, develops a project (e.g., guidebook, manual, online documentation, website, video, podcast) and completes a paper describing the theory and methodology supporting the project application. Submission of the MSPTC ePortfolio demonstrating proficiency is required for graduation.

PTC 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until thesis in completed. Total will be limited to 6 credits.

PTC 701B. Master'S Thesis. 3 credits, 3 contact hours.
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until thesis in completed. Total will be limited to 6 credits.

PTC 701C. Master'S Thesis. 6 credits, 3 contact hours.
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until thesis in completed. Total will be limited to 6 credits.

PTC 725. Independent Study in Professional and Technical Communication. 3 credits, 3 contact hours.
Prerequisite: approval of graduate advisor and supervising faculty.Allows development of areas of specialization for Master's Project or for areas of study in communication in which one or more students may be interested but which are not of sufficiently broad interest to warrant a regular course offering.

PTC 726. Independent Study II. 3 credits, 3 contact hours.

Applied Science

The Graduate Certificate in Applied Science (APSC) is a program representing many of NJIT's academic departments and colleges. The multitude concentrations within the program are brought together by Dr. Andrew Klobucar from the NJIT Department of Humanities into one cohesive unit of learning, with his expertise in technical writing and instructional design. The primary objective of the program is to 'educate the educators' in a concentrated science field at a high level, and apply current instructional design tools in that science field, to bring back to the classroom on their own. By no means is the program exclusive to educators - anyone qualified may take it! Click here to download the program brochure (http://www.njit.edu/graduatestudies/file/cert-applied-science-teachers-flyer-draftpdf/).

Who would be suited to take this program?

This graduate certificate is primarily for secondary school teachers who want to strengthen their background in science, business, computing, engineering, architecture and/or technical communication. Students may choose from ten tracks. Those teaching AP (Advanced Placement) courses in secondary schools will benefit substantially from the certificate courses.

What are the Required Courses?

Code	Title	Credits
Core Courses (choose 2 courses)		**6**
PTC 681	Tech in Class & Learning Envir	
PTC 698	Selected Topics in Professional and Technical Communication	
Tracks(choose 1 track; take 9 credits)		**9**
Professional and Technical Communication		
Choose 3 Courses (9 credits)		9
PTC 603	Identity, Technology, and Communication	
PTC 629	Theory and Practice of Social Media	
PTC 601	Advanced Professional and Technical Communication	
PTC 605	Elements of Visual Design *	
Business		
Choose 3 Courses (9 credits)		9
MGMT 620	Management of Technology	
ECON 610	Managerial Economics	
FIN 600	Corporate Finance I	
FIN 624	Corporate Finance II	
MGMT 635	Data Mining and Analysis	
MGMT 640	New Venture Management	
MGMT 650	Knowledge Management	
MGMT 691	Legal and Ethical Issues	
MGMT 692	Strategic Management	
Computer Science		
Choose 3 Courses (9 credits)		9
CS 505	Programming, Data Structures, and Algorithms	
CS 506	Foundations of Computer Science	
CS 610	Data Structures and Algorithms	
CS 630	Operating System Design	
CS 631	Data Management System Design	
CS 656	Internet and Higher-Layer Protocols	
Engineering Management		
Choose 3 Courses (9 credits)		9
EM 636	Project Management	
HRM 601	Organizational Behavior	

ACCT 615	Management Accounting	
IE 673	Total Quality Management	
MIS 645	Information Systems Principles	
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 637	Project Control	
EM 691	Cost Estimating for Capital Projects	
EM 632	Legal Aspects in Construction	
Information Systems		
Choose 3 Courses (9 credits)		9
IS 601	Web Systems Development	
IS 663	System Analysis and Design	
IS 631	Enterprise Database Management	
IS 665	Data Analytics for Info System	
IS 676	Requirement Engineering	
IS 678	IT Service Management	
IS 680	Information Systems Auditing	
IS 681	Computer Security Auditing	
IS 684	Business Process Innovation	
IS 688	Web Mining	
Engineering		
Choose 3 Courses (9 credits)		9
IE 604	Advanced Engineering Statistics	
IE 621	Systems Analysis and Simulation	
ECE 601	Linear Systems	
ECE 605	Discrete Event Dynamic Systems	
ECE 673	Random Signal Analysis I	
IE 618	Engineering Cost and Production Economics	
IE 672	Industrial Quality Control	
IE 673	Total Quality Management	
ME 616	Matrix Methods in Mechanical Engineering	
ME 632	Mechanical Engineering Measurements	
BME 669	Engineering Physiology	
BME 670	Introduction to Biomechanical Engineering	
BME 675	Computer Methods in Biomedical Engineering	
Architecture		
Choose 3 Courses (9 credits)		9
ARCH 545G	Structures I	
ARCH 548G	Structures II *	
ARCH 555G	Architectural Graphics	
ARCH 500G	Advanced Architectural Graphics	
ARCH 528G	History of Architecture I	
ARCH 529G	History of Architecture II	
ARCH 541G	Construction I	
ARCH 542G	Construction II	
ARCH 543G	Environmental Control Systems I	
ARCH 544G	Environmental Control Systems II	
ARCH 569G	Building and Development	
Chemistry		
Choose 3 Courses (9 credits)		9
CHEM 605	Advanced Organic Chemistry I: Structure	
CHEM 661	Instrumental Analysis Laboratory	
CHEM 673	Biochemistry	

CHEM 777	Principles Pharm Chemistry	
EVSC 616	Toxicology	
EVSC 610	Environmental Chemical Science	
Mathematics		
Choose 3 Courses (9 credits)		9
MATH 545	Introductory Mathematical Analysis	
MATH 546	Advanced Calculus	
MATH 611	Numerical Methods for Computation	
MATH 630	Linear Algebra and Applications	
MATH 660	Introduction to statistical Computing with SAS and R	
MATH 661	Applied Statistics	
Physics		
Choose 3 Courses (9 credits)		9
PHYS 611	Adv Classical Mechanics	
PHYS 621	Classical Electrodynamic	
PHYS 641	Statistical Mechanics	
PHYS 661	Solid-State Physics	
PHYS 607	Topics in Astronomy and Cosmology	
Total Credits		15

* indicates as available online

What will I learn?

Technology in the classroom and learning environments, digital instructional design, and a track of your choice:

- *Technology in Class and Learning* - Various types of technology necessary to develop, use, and process the results of assessments as well as facilitate and augment instructional design. The integration of present and likely future technology into instruction to foster community, collaboration, conceptual development, and exceptional academic performance as well as a more effective and well-understood assessment system.
- Digital Instruction Essentials - The digital era has placed teaching and learning in flux, creating instructional opportunities at every turn. In this course students will examine the fundamentals of instructional design, working through a cycle of continuous improvement including idea generation, curriculum development, course production, and assessment. Students will explore and discuss scholarly research about the impact of mobile technology, big data, gamification, MOOCs, and universal design on today's learning environments. This course will borrow some ideas from agile methodology in hopes that it drives us to be better designers; we want to incorporate simplicity, feedback, communication, and courage into everything we do. That doesn’t have to be limited to what we design, but it can be part of how this course runs for you.
- *Custom Elective Track* - A selection of courses from Professional and Technical Communication, Business, Computer Science, Engineering Management, Information Systems, Engineering, Architecture, Chemistry, Mathematics, or Physics.

Why study Applied Science at NJIT?

The graduate certificate allows you to choose the area of speciality that you would like to enhance, in your career. Whether you are a Chemistry middle school teacher, or a corporate instructional designer, this program will help improve your everyday methodology.

Prerequisites and Competion Requirements

Applicants are expected to be practicing secondary school teachers who have a bachelor’s degree. Students who lack an appropriate background for their chosen track, or prerequisites for a particular course that they plan to take, may be asked to take one or more bridge/undergraduate courses that will not count toward the degree requirements. Students must choose one of the ten tracks (that represent specific disciplines) and successfully complete 15 credits.

Related Degree Programs

All credits for the Applied Science Graduate Certificate relates in its entirety to NJIT MS in Applied Science (http://www.njit.edu/online/ms-applied-science/).

NJIT K-12 Teacher Scholarship

This is an NJIT award available to any K-12 teachers who are residents of New Jersey, New York, Pennsylvania, and Delaware enrolled in the Applied Science Master Degree or Graduate Certificate in Applied Science Programs (On-campus or Online). The recipient will receive up to 35% of his/her tuition charge in scholarship. The award is renewable for the duration of the program. You must provide a copy of your teaching license or submit a letter of employment as a teacher from your school district prior to enrollment to be considered for the scholarship. You must be a U.S.

citizen or a permanent resident to be eligible. You must maintain a cumulative GPA of 3.0/4.0. Please complete this form to submit your information for consideration for the scholarship (https://docs.google.com/forms/d/e/1FAIpQLSczruWuu3X_FnUUtwW9lk69uVh2Ce0YHDFN2A4CqEaxls8CNA/viewform/?usp=sf_link).

Faculty Advisor: Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)

Digital Marketing Design Essentials

This interdisciplinary certificate focuses on the use and impact of digital media in marketing communications. Students will gain competencies in information technologies, social media, and organizational cultures.

Its collaborative approach will grant students the flexibility to study the utilization and impact of media, particularly digital media, through the degree program's courses. Students will gain a competitive advantage by being trained to promote more effective practice of the social, cultural, and economic dynamics of digital media marketing.

Who would be suited to take this program?

This certificate is suited for students and professionals interested in the aesthetic and societal aspects of technology, and who intend to learn/expand their careers in communication media, corporate and other public relations, visual arts, publishing, social media and public policy.

Career options may include data analysis manager, social media manager, digital marketing manager, and content strategy manager.

What are the Required Courses?

Code	Title	Credits
Core Courses		
PTC 628	Analyzing Social Networks	3
PTC 642	Corporate Media and Communication	3
MRKT 645	Internet Marketing Strategy	3
Select one of the following:		3
MGMT 635	Data Mining and Analysis	
IS 665	Data Analytics for Info System	

What will I learn?

- Introduction to the use of the Internet and electronic commerce in the development of marketing strategy.
- The development of Internet-based marketing.
- An overview of social networks by introducing them to the unique terminology of social networks.
- Positive and negative characteristics of social networks will be discussed, followed by visualizations and analyses of those characteristics.
- Introduction to data analysis, probability and statistics from an information systems perspective, including many of the techniques that are most relevant to the profession of Data Scientist for business, data and web analytics, as well as current data sets.
- The rudiments of probability and random variables, estimation, special distribution and sampling, Markov processes, hypothesis testing, graphics and visualization.

Why study Digital Marketing Essentials at NJIT?

Student will gain a competitive advantage by being trained to promote more effective practice of the social, cultural, and economic dynamics of digital media. This forecast is supported by rapidly increasing activity within the investment community into digital marketing and content management industries, and aggressive strategic redirection within telecommunications, media and advertising companies to exploit the new delivery channels, analytics, and client behaviors (consumer and industrial) afforded by the deployment of the underlying technology. Importantly, NJIT is located at the epicenter of this activity.

Prerequisites

NJIT standard admission requirements apply to this graduate certificate. Applicants may require a corequisite: PTC 601, an undergraduate course in probability and statistics, and undergraduate-level programming, per academic advisement.

Related Degree Programs

This credential relates in its entirety to NJIT MS Professional and Technical Communication (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Faculty Advisor: Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)

Instructional Design, Evaluation, and Assessment

The Instructional Design, Evaluation, & Assessment track is designed to teach students to build quality educational experiences at varying levels for diverse learner populations for any discipline of study or subject matter.

This certificate is directed at K through 16 teachers and administrators faced with instructional design and educational measurement demands in a culture of accountability. But education now exists outside the formal classroom. Digital educators need to learn and stay abreast with the tools used in this area.

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/Certificate_IDEA.pdf) for a program brochure.

Who would be suited for this program?

Administrators, online learning specialists, educational technologists, technical trainers, corporate trainers, and government officials, may benefit from the program.

Anyone advancing their career working in education, corporate training, program assessment, or any areas that require instruction and/or evaluation of content tied to target learning and mastery of that content.

What are the Required Courses?

Code	Title	Credits
Core Courses		
Select four of the following		12
PTC 606	Advanced Information Design	
PTC 610	Research Methods for Information Design	
PTC 681	Tech in Class & Learning Envir	
PTC 698	Selected Topics in Professional and Technical Communication	

What will I learn?

Students will learn to critically analyze learning situations in order to develop integrated plans for curriculum and assessment systems to attain learning goals and demonstrate desired outcomes for learners. Seamless integration of technology awareness and application will augment the study of theory and research to foster creativity and problem-solving skills to plan, assess, and improve learning

The mission of the IDEA track is to prepare the students to know and effectively work with the essentials of assessment, program evaluation, and measurement in order to more effectively design, develop, implement, update, and assess curriculum to promote learner mastery. The combination of the core courses and electives will provide students the opportunity to gain a strong basis in the theory and practice of evaluation, assessments and instructional design so that these areas can work together and complement one another.

- Advanced Information Design will cover the design and creation of multimedia objects, usability heuristics, navigation theory, contemporary design practices and online community building. Students will be required to create media-rich multidimensional online projects that encourage and facilitate interaction and team-building in the online environment
- Research Methods for Information Design introduces user research methods such as contextual inquiry, ethnographic field studies, card sorting, affinity diagramming, and usability testing that provide the foundation for user- centered interaction design.
- Technology in Classrooms & Learning Environments examines the various types of technology necessary to develop, use, and process the results of assessments as well as facilitate and augment instructional design. This course examines the integration of present and likely future technology into instruction to foster community, collaboration, conceptual development, and exceptional academic performance as well as a more effective and well-understood assessment system.
- Instructional Design and Assessment will review the forms of writing central to academic research. Students will review literature, peer-review the work of others, prepare conference material, and produce a submission-quality journal or conference paper in their field of study.

Why study IDEA at NJIT?

Offered online, with hybrid meeting times for those with geographic proximity to Newark and synchronous communication opportunities for those in remote locations, the core courses will allow busy working professionals the opportunity to earn a graduate degree in an area relevant to their professional development. Elective specializations in NJIT curricular areas such as professional and technical communication, computer information science, and statistics will allow further development. Upon approval, electives may be taken at relevant graduate programs across the nation.

Prerequisites

Completion of a Bachelor's degree with a overall cumulative Grade Point Average of 2.8 or higher on a 4.0 scale.

Related Degree Programs

This credential relates in its entirety to NJIT MS in Professional and Technical Communication (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Faculty Advisor: Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)

M.S. in Applied Science

This is a multidisciplinary program for secondary school teachers to strengthen their background in science, business, computing, engineering, architecture and/or technical communication.

Admission Requirements

Applicants should be practicing secondary school teachers who have a bachelor's degree. Individuals who seek admission to the program are considered on an individual basis and will be advised in choosing a track matching their teaching assignments as teachers. Students who lack an appropriate background for their chosen track or a particular course that they plan to take may be asked to take one or more bridge/undergraduate courses that will not count toward the degree requirements.

Degree requirements

Students must successfully complete 30 credits:

- 9 credits of core courses;
- 3 credits of master's project or 6 credits of master's thesis;
- 15 credits of courses in the chosen track when choosing the project option

or 12 credits of courses in the chosen track when choosing the thesis option; and

- at least 3 credits of additional elective courses (elective courses can be from other tracks if the student has the required background or prerequisites).

Core Courses

Code	Title	Credits
Choose 3 courses(9 credits):		
PTC 603	Identity, Technology, and Communication	3
PTC 629	Theory and Practice of Social Media	3
PTC 681	Tech in Class & Learning Envir	3
PTC 698	Selected Topics in Professional and Technical Communication	3

Tracks

Code	Title	Credits
Business		
Required Courses (3 credits)		
MGMT 620	Management of Technology	
Additional Courses (choose 3 or 4 courses to earn 9 or 12 credits)		
ECON 610	Managerial Economics	
FIN 600	Corporate Finance I	
FIN 624	Corporate Finance II	
MGMT 635	Data Mining and Analysis	
MGMT 640	New Venture Management	
MGMT 650	Knowledge Management	
MGMT 691	Legal and Ethical Issues	
MGMT 692	Strategic Management	
Computer Science		
Required Courses (6 credits)		
CS 505	Programming, Data Structures, and Algorithms	

CS 506	Foundations of Computer Science
Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
CS 610	Data Structures and Algorithms
CS 630	Operating System Design
CS 631	Data Management System Design
CS 656	Internet and Higher-Layer Protocols
Engineering Management	
Required Courses (6 credits)	
EM 636	Project Management
HRM 601	Organizational Behavior
Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
ACCT 615	Management Accounting
IE 673	Total Quality Management
MIS 645	Information Systems Principles
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers
EM 637	Project Control
EM 691	Cost Estimating for Capital Projects
EM 632	Legal Aspects in Construction
Information Systems	
Required Courses (6 credits)	
IS 601	Web Systems Development
IS 663	System Analysis and Design
Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
IS 631	Enterprise Database Management
IS 665	Data Analytics for Info System
IS 676	Requirement Engineering
IS 678	IT Service Management
IS 680	Information Systems Auditing
IS 681	Computer Security Auditing
IS 684	Business Process Innovation
IS 688	Web Mining
Engineering	
Required Courses (6 credits)	
IE 604	Advanced Engineering Statistics
IE 621	Systems Analysis and Simulation
Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
ECE 601	Linear Systems
ECE 605	Discrete Event Dynamic Systems
ECE 673	Random Signal Analysis I
IE 618	Engineering Cost and Production Economics
IE 672	Industrial Quality Control
IE 673	Total Quality Management
ME 616	Matrix Methods in Mechanical Engineering
ME 632	Mechanical Engineering Measurements
ME 635	Computer-Aided Design
BME 669	Engineering Physiology
BME 670	Introduction to Biomechanical Engineering
BME 675	Computer Methods in Biomedical Engineering
Architecture	
Required Courses (6 credits)	
ARCH 545G	Structures I
ARCH 548G	Structures II

Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
ARCH 555G	Architectural Graphics
ARCH 500G	Advanced Architectural Graphics
ARCH 528G	History of Architecture I
ARCH 529G	History of Architecture II
ARCH 541G	Construction I
ARCH 542G	Construction II
ARCH 543G	Environmental Control Systems I
ARCH 544G	Environmental Control Systems II
ARCH 569G	Building and Development
Chemistry	
Required Courses (6 credits)	
CHEM 605	Advanced Organic Chemistry I: Structure
CHEM 661	Instrumental Analysis Laboratory
Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
CHEM 673	Biochemistry
CHEM 777	Principles Pharm Chemistry
EVSC 616	Toxicology
EVSC 610	Environmental Chemical Science
Mathematics	
Required Courses (6 credits)	
MATH 545	Introductory Mathematical Analysis
MATH 546	Advanced Calculus
Additional Courses (choose 2 or 3 courses to earn 6 or 9 credits)	
MATH 611	Numerical Methods for Computation
MATH 630	Linear Algebra and Applications
MATH 660	Introduction to statistical Computing with SAS and R
MATH 661	Applied Statistics
Physics	
Required Courses (3 credits)	
PHYS 611	Adv Classical Mechanics
Additional Courses (choose 3 or 4 courses to earn 9 or 12 credits)	
PHYS 621	Classical Electrodynamic
PHYS 641	Statistical Mechanics
PHYS 661	Solid-State Physics
PHYS 607	Topics in Astronomy and Cosmology

Custom track

Students may develop an individual track in consultation with a graduate advisor. A coherent set of courses involving mathematics, computing, physics, chemistry, biology or engineering are expected.

M.S. in Professional and Technical Communication

Degree Requirements

Students must complete a minimum of 30 degree credits taken over a minimum of two semesters. Five core courses must be completed by all students; five elective courses allow students to specialize in selected areas of professional and technical communication.

Students must design and maintain an ePortfolio of work completed within the courses. This work, organized around core competencies within each seminar in the program, will be reviewed by the instructional faculty every semester. In the final semester before graduation, students are required to submit their portfolio for non-credit assessment in PTC 691 ePortfolio Capstone Seminar.

Code	Title	Credits
Core Courses		
PTC 601	Advanced Professional and Technical Communication	3

PTC 603	Identity, Technology, and Communication	3
PTC 604	Communication Theory and Research	3
PTC 605	Elements of Visual Design	3
PTC 606	Advanced Information Design	3
ePortfolio		
PTC 691	ePortfolio Capstone Seminar	0
Elective Courses		
Select five of the following:		15
PTC 610	Research Methods for Information Design	
PTC 612	Theory and Practice of Text Encoding	
PTC 620	Proposal Writing	
PTC 622	Working in Teams: Collaborative and Interpersonal Communications	
PTC 624	Professional and Technical Editing	
PTC 626	Communication Media Design Studio	
PTC 628	Analyzing Social Networks	
PTC 629	Theory and Practice of Social Media	
PTC 631	Communication and Environmental Problem Solving	
PTC 632	Content Management and Information Architecture	
PTC 640	Health Communications	
PTC 642	Corporate Media and Communication	
PTC 644	Communication in Technology Transfer and Innovation	
PTC 650	eLearning Design for Mobile	
PTC 672	Design Instruction Assess Meth	
PTC 681	Tech in Class & Learning Envir	
PTC 698	Selected Topics in Professional and Technical Communication	
PTC 700	Master'S Project	
PTC 701	Master'S Thesis	
PTC 725	Independent Study in Professional and Technical Communication	
Total Credits		30

Social Media Essentials

Today's innovations in communication have created an undeniable demand for specialists in social media. Corporations, governments, and non profits are engaging in digital media to extend the reach of their initiatives providing a fresh platform for launching new products and services. Graduates from this certificate program will know when and how to use media tools to foster dialogue and drive action. Students will gain competencies in communication, information design, and new technologies.

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/Certificate_SME.pdf) for a program brochure.

Who is this program recommended for?

This program, which is completely available online, is ideal for working professionals who want or need to update skills for their current profession. Students who want to change careers and enter the field of social media will also gain from this certificate. Corporations, government, big and small businesses all need the expertise of specialists in social media.

What are the Required Courses?

Code	Title	Credits
Core Courses		
Select four of the following:		12
PTC 606	Advanced Information Design	3
PTC 610	Research Methods for Information Design	3
PTC 628	Analyzing Social Networks	3
PTC 629	Theory and Practice of Social Media	3

What will I learn?

- Deep understanding of the relationship between communication, design, and technology
- Professional use of social media as communication tools in business, education, by non-profits and as communities of interest
- How and when to use blogging, tagging, wiki writing, podcasting, and tweeting.
- Social media strategies for reading and writing in today's multi-cultural, screen-oriented, networked culture.
- Detailed understanding of online visual communication strategies and community building -- design and creation of multimedia objects, usability heuristics, navigation theory, contemporary design practices and online community building
- User research methods such as contextual inquiry, ethnographic field studies, card sorting, affinity diagramming, and usability testing that provide the foundation for user-centered design
- User and task analysis, rhetorical strategies
- Contemporary types of technical communication
- Comprehensive professional ePortfolio of your work that will enhance your résumé

Why study Social Media Essentials at NJIT?

NJIT, at the leading edge of technology and science, provides the technical backbone for a program involving social media. Several market indicators point to this field as a strong career choice for 2010 and beyond. The United States Department of Labor, *US News and World Report*, and *The Wall Street Journal* have all recently identified expertise in social media as a knowledge area in high demand.

Prerequisites

NJIT standard admission requirements apply to this graduate certificate. In addition:

1. High-speed internet connection access from a computer that is not behind a firewall. Access to Moodle and to synchronous chat are often prevented by many companies' security policies. Please check with your company if you plan to access this course from work.
2. Familiarity with using the computer as a tool of learning.
3. Fluency with Microsoft Word, and confidence in exploring the Internet.
4. Commitment to distance learning as a mode of education. You should be prepared to visit the course Web site daily and post observations in discussion groups. If technical problems arise, you will not let these stand in the way of obtaining material and submitting work.

Related Degree Programs

This credential relates in its entirety to NJIT MS in Professional and Technical Communication (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Faculty Advisor: Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)

Technical Communication Essentials

The Technical Communication Essentials Graduate Certificate prepares students to communicate in rapidly changing technology fields. Students gain skills and knowledge in technical writing and editing, documentation, content management, and web-based training.

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/Certificate_TCE.pdf) for a program brochure.

Who is suited for this program?

This Certificate is primarily suited for professionals who intend to learn/expand their careers as technical writers, editors, trainers, website designers, and documentation specialists. Instructors using new technologies in the classroom or via corporate education will also find interest in this program.

What are the Required Courses?

Code	Title	Credits
Core Courses		
Select four of the following:		12
PTC 601	Advanced Professional and Technical Communication	3
PTC 605	Elements of Visual Design	3
PTC 624	Professional and Technical Editing	3
PTC 632	Content Management and Information Architecture	3

What will I learn?

- Advanced Professional and Technical Communication which introduces students to the profession and the academic discipline of technical/ professional communication. It includes usability analysis; visual information; ethics; global communication; report writing; information literacy; communicating with new technologies; and technical writing style.
- Elements of Visual Design which integrates theories of design, techniques of composition, and technologies of electronic and print publishing.
- Content Management and Information Architecture will focus on the use of Information Architecture methodologies (such as, DITA or DocBook) to develop a structure for presenting technical information and on Content Management tools for creating a single source repository for this information. In-demand proprietary software free to students in course.
- Professional and Technical Editing includes correctness and conciseness, hard copy and on-line editing, editing graphics, document management, editor-author relationships, and ethical considerations in editing.
- eLearning Design for Mobile is a critical skill for today's technical communicator. Specific skills and tools are required to ensure a successful implementation. Based on proven user centered design concepts, this course provides the student with the skills necessary to create effective mobile training programs.. In-demand proprietary software free to students in course.

Why study Technical Communication Essentials at NJIT?

The graduate certificate's narrow focus allows you to dig deep into this specific topic, and start applying your knowledge sooner. It is possible to earn this certificate fully through online courses. And, in doing so, you'll learn from NJIT's distinguished professors and instructors.

Prerequisites

NJIT standard admission requirements apply to this graduate certificate.

Related Degree Programs

This credential relates in its entirety to NJIT MS in Professional and Technical Communication (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/technical-communication-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)

User Experience Essentials

User experience design is a radically changing area of both research and implementation. Whether it is a part of new apps, websites, or touchscreens at the supermarket, there is a designer behind each interactive product, implementing useful ideas and tools to the consumer in such a way that they would be happy to engage with. This is the basis for User Experience Design (UX). The graduate certificate in User Experience Essentials (UXE) exposes students to the process of usability testing and knowledge transfer between general audiences, technology designers, programmers, project managers, and administration.

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/Certificate_UXE.pdf) for a program brochure.

Who is this program recommended for?

The graduate certificate will expose students to user experience practice and theory, cultivating skills applicable to professionals working in such fields as community management, marketing, sales, social media and web analytics, public relations, and media consulting. Some occupations include mobile application developers, website designers, instructors, digital artists, UI and product designers

What are the Required Courses?

Code	Title	Credits
Core Courses		
Select four of the following:		12
PTC 604	Communication Theory and Research	3
PTC 610	Research Methods for Information Design	3
PTC 650	eLearning Design for Mobile	3
PTC 698	Selected Topics in Professional and Technical Communication	3

What will I learn?

Students completing the graduate certificate in UXE students will become familiar with diverse and broadly applicable skills, as well as knowledge and theoretical underpinnings in a range of communications and user experience topics, including:

- Audience analysis (e.g., audience theory and research traditions, audience formation, and experience, reception studies, etc.)
- User experience theories and applications (e.g., uses and gratifications, media functions versus media use, information-processing theory, etc.)
- Empirical communications research methodologies (e.g., content analysis, focus groups, in-depth interviews, thematic analysis, and surveys)
- The ability to draw inferences and make actionable recommendations based on user experience data
- Experience in collecting and analyzing a broad range of user-based data, with an emphasis on research design that is user-centered, process-oriented, and motivated by outcomes

Why study User Experience Essentials at NJIT?

NJIT has been educating technical professionals for more than 125 years. At the intersection of technology and applied science, NJIT provides the necessary technical backbone for a program involving communications, technology, and research. With a major technological research university as its home, the graduate program in user experience emphasizes a research-driven approach to problem-solving using the most modern technologies, tools, and digital platforms.

Prerequisites

Applicants must have a bachelor’s degree from an accredited institution with a cumulative undergraduate GPA of at least 2.8 on a 4.0 scale. NJIT standard admission requirements (https://www.njit.edu/admissions/how-apply-graduate-admissions/) apply to this graduate certificate.

Related Degree Programs

This credential relates in its entirety to NJIT MS in Professional and Technical Communication (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/humanities/professional-technical-communication-ms/)

Faculty Advisor: Andrew Klobucar (http://directory.njit.edu/PersDetails.aspx?persid=klobucar)

Mathematical Sciences

Master of Science in Applied Mathematics

This program is intended for students with a strong interest in Applied Mathematics. Applied Mathematics is the application of classical and modern mathematical techniques to the solution of practical problems in the physical and biological sciences and engineering. The applied mathematician develops and analyzes mathematical models of physical and biological phenomena and engineering systems, interprets solutions to mathematical problems and uses the results to identify relationships, patterns, and the effects of altering one or more variables or modeling assumptions. Many of the courses in the program illustrate how mathematics can be used to predict the behavior of physical, biological, and engineering systems.

The **Master of Science in Applied Mathematics**, with its areas of specialization in analysis, applied mathematics, computational methods, and mathematical biology is designed to serve the needs of students who may be interested in pursuing a doctoral degree in the mathematical, physical, or biological sciences. The program also strengthens the quantitative and analytical skills of students with a baccalaureate degree who are planning to work in industry, commerce, or education, as well as practicing engineers and others already employed in industry and commerce.

Admission Requirements

It is expected that students applying for admission will have an undergraduate education in mathematics, the physical or biological sciences, or engineering. For additional information, see the Admissions section of this catalog. An undergraduate GPA of at least 2.8 on a 4.0 scale or equivalent is normally required. GRE scores are required for those students applying for financial support, or if the most recent degree was earned at a school outside the United States. Applications are considered on a case-by-case basis.

Master of Science in Applied Statistics

The objective of the **Master of Science in Applied Statistics** is to prepare students for a wide range of professional activities as practicing statisticians in both academia and industry. A statistician develops and analyzes models of data-driven situations where uncertainty of the outcomes plays a major role, identifies statistical relationships among observable variables, forecasts probable future outcomes, and draws inferences about background parameters that impact the phenomenon of interest. Thus the program is designed to provide students with the comprehensive knowledge and technical skills that are needed for the planning, execution, and analysis of statistical studies. These statistical studies are increasingly used as advisory instruments for policy decisions in the corporate and other sectors of the economy.

The Master of Science in Applied Statistics program will serve the needs of students with a baccalaureate degree who are planning to work in industry, commerce, or education, as well as practicing engineers and others already employed in industry and commerce. The program also strengthens the analytical and quantitative skills of graduate students who may be interested in pursuing a doctoral degree in Applied Probability and Statistics, since it equips them with basic training in the foundations of statistics in preparation for further advanced studies and research.

Admission Requirements

Applicants must have a degree from an accredited institution with at least 12 credits in mathematics, including calculus. Students who do not meet these requirements may be admitted if they satisfy the university's requirements for admission. An undergraduate GPA of at least 2.8 on a 4.0 scale or equivalent is normally required. GRE scores are required for those students applying for financial support, or if the most recent degree was earned at a school outside the United States. Applications are considered on a case-by-case basis.

Bridge Program: Students who do not satisfy the credit requirement in mathematics will be required to take a bridge program of six credits in appropriate mathematics courses. Such courses do not count towards a graduate degree.

Master of Science in BioStatistics

The **Master of Science in Biostatistics** will provide advanced graduate education and training to students interested in applying statistical methods to the health sciences in general and clinical studies in particular. It will focus on training students in quantitative methods that will prepare them for careers in the health, life sciences, and pharmaceutical areas. Graduates, upon satisfactory completion of the degree program, are expected to have acquired appropriate skills in data analysis and computing that are typically required in their profession. This program will address the growing demand for trained biostatisticians in these fields, especially in New Jersey.

Admission Requirements

Applicants must have a baccalaureate degree in Statistics, Mathematics, Sciences, or Engineering, with at least 12 credits in mathematics, including calculus and at least one upper division course in statistics. Applicants with other baccalaureate degrees will also be considered and may be subject to a suitable bridge program. An undergraduate GPA of at least 3.0 on a 4.0 scale or equivalent is required.

Bridge Program: Students who do not satisfy the credit requirement in mathematics will be required to take a suitable bridge program of appropriate mathematics/statistics courses. Such courses do not count towards the graduate degree.

Master of Science in Mathematical and Computational Finance

The **M.S. in Mathematical and Computational Finance (MSMCF)** at NJIT provides students with the mathematical and computational tools and with the understanding of financial instruments and markets needed to obtain positions as quantitative analysts in financial institutions including Wall Street investment firms.

The **Applied Quantitative Finance Option** is designed to combine strong technical knowledge with the professional skills required for senior positions in industry, including emphasis on collaborative projects, communication, and project management.

Who should enroll?

The **Master of Science in Mathematical and Computational Finance** provides students with the theoretical knowledge as well as the practical methods and skills needed to begin or enhance careers as quantitative analysts in the financial industry. Because of the evolving nature of financial markets and institutions, practitioners in this field must be ready to learn new ideas and methods across a broad range of disciplines including mathematics, statistics, computational science, finance, and economics. The program aims to provide the multidisciplinary foundations preparing quantitative analysts for this life-long development of skills and understanding. Students should have a mathematical background equivalent to that of a typical undergraduate major in the engineering, physical, or mathematical sciences.

Admission Requirements

Undergraduate courses in multivariable calculus, probability theory, statistical inference, linear algebra, and differential equations.

How can I find out more?

- MSMCF Program Guide (https://math.njit.edu/sites/math/files/lcms/docs/MSMCF_Program_Guide_1_4.pdf)
- Attend a graduate student open house (http://www.njit.edu/admissions/visit/graduateopenhouses.php).
- Request information from our Admissions Office (http://www.njit.edu/admissions/graduate/).

Why Study Mathematical Finance at NJIT?

Quantitative finance is an established discipline within the financial, investment, banking, and insurance industries and increasingly critical in regulatory agencies. As the financial industry is highly concentrated around the New York City area, quantitative financial engineers are in high demand locally. Mathematical and computational tools are at the heart of these activities. Practitioners combine high-level analytical, computational and modeling skills with a thorough understanding of financial markets and instruments to assess value and risk. The Department of Mathematical Sciences at NJIT has national prominence in several fields of applied mathematics, and annually obtains research funding from national agencies including The

National Science Foundation, the National Institutes of Health, the Howard Hughes Institute of Medical Research, the Office of Naval Research, and the Department of Energy. The department has a thriving doctoral program as well as masters programs in applied mathematics and applied statistics.

GRE or GMAT scores are required for those students applying for financial support, or if the most recent degree was earned at a school outside the United States. Applications are considered on a case-by-case basis. Required courses for the program are generally offered in the evenings and part-time study is possible.

Bridge Program: Students with a baccalaureate degree not fully covering the prerequisites listed above may be admitted and required by the department to take an individually-designed program of courses that may include undergraduate courses before proceeding to the graduate curriculum. Such courses do not count towards a graduate degree.

Doctor of Philosophy in Mathematical Sciences

The **Doctor of Philosophy in Mathematical Sciences** is offered in collaboration with the Department of Mathematics and Computer Science at Rutgers University-Newark. The doctoral program in Mathematical Sciences is designed to prepare students for a wide range of professional activities in science and engineering. Prospective students must choose one of the following tracks:

- Applied Mathematics
- Applied Probability and Statistics
- Pure Mathematics

The doctoral program reflects the research interests of the faculty and is focused on the development and use of mathematical tools for solving modern scientific, technological and industrial problems, and advancing the research knowledge and methodology in various fields of specialization.

The Applied Mathematics track emphasizes the applications of mathematical methods to the physical and biological sciences and engineering, including acoustics, electromagnetics, fluid dynamics, materials science, biology, and medicine. Mathematical modeling, asymptotic analysis, and scientific computing are emphasized. Students are expected to develop a broad range of capabilities both in mathematics and in an area of application.

The Applied Probability and Statistics track emphasizes directed instruction and independent research in areas that are specializations of the faculty. Current research interest areas of the faculty include applied probability, non-parametric statistics, and statistical reliability theory and applications

The Pure Mathematics track offers research opportunities in many fields of specialization, including representation theory, number theory, low-dimensional topology, Riemann surfaces and Kleinian groups, geometric group theory, and 4-manifolds.

Admission Requirements

Admission to the program is based on a review of the applicant's credentials and interests as expressed in academic transcripts, GRE scores, letters of recommendation, statement of interests, and TOEFL scores (for students whose native language is not English). Applicants with strong academic records whose abilities and interests complement the research of the faculty are sought. In general, applicants should have a bachelor's or master's degree in mathematics, an engineering discipline, or a branch of the natural sciences. Students choosing the Applied Mathematics track or the Applied Probability and Statistics track must fulfill the admissions requirements specified in the Admissions section of this catalog.

Students interested in either the Applied Mathematics track or the Applied Probability and Statistics track should apply to NJIT. Students interested in the Pure Mathematics track should apply to Rutgers-Newark.

NJIT Faculty

A

Afkhami, Shahriar Zakerzadeh, Associate Professor

Ahluwalia, Daljit Singh, Professor Emeritus

Andrushkiw, Roman, Professor Emeritus

B

Batson II, William Richard, Post Doctoral Fellow

Bechtold, John K., Professor

Blackmore, Denis L., Professor

Booty, Michael R., Professor

Bose, Amitabha K., Professor

Boubendir, Yassine, Associate Professor

Brown, Ronald Robert, University Lecturer

Bukiet, Bruce G., Associate Professor

C

Choi, Wooyoung, Professor

Cummings, Linda J., Professor

D

Dhar, Sunil K., Professor

Diekman, Casey O., Assistant Professor

Dios, Rose, Associate Professor

F

Fang, Yixin, Associate Professor

Froese, Brittany, Assistant Professor

G

Garfield, Ralph, Associate Professor Emeritus

Goodman, Roy H., Associate Professor

Guo, Wenge, Associate Professor

H

Hayes, Jimmy L., University Lecturer

Horntrop, David J., Associate Professor

Horwitz, Kenneth A., University Lecturer

Hunter, John, University Lecturer

J

Jiang, Shidong, Associate Professor

K

Kappraff, Jay M., Associate Professor

Kelly, Rudy, University Lecturer

Kondic, Lou, Professor

Kriegsmann, Gregory A., Distinguished Professor Emeritus

L

Loh, Ji Meng, Associate Professor

Luke, Jonathan H. C., Professor

M

Matveev, Victor V., Associate Professor

Michalopoulou, Zoi-Heleni, Professor

Milojevic, Petronije, Professor

Miura, Robert M., Distinguished Professor Emeritus

Mohebbi Forushani, Soroosh, University Lecturer

Moore, Richard O., Associate Professor

Muratov, Cyrill B., Professor

N

Natarajan, Padma, University Lecturer

P

Perez, Manuel, Professor

Petropoulos, Peter G., Associate Professor

Plastock, Roy A., Associate Professor

Pole, Andrew, MSMCF Coordinator

Porus, Jonathan J, Math Tutoring Center Director

Potocki-Dul, Magdallena M., University Lecturer

R

Rappaport, Karen D., Senior University Lecturer

Ratnaswamy, Jeyakumaran, Senior University Lecturer

Rotstein, Horacio G., Professor

S

Shirokoff, David, Assistant Professor

Siegel, Michael S., Professor

Stickler, David, Professor Emeritus

Subramanian, Sundarraman, Associate Professor

T

Tavantzis, John, Professor Emeritus

Turc, Catalin C., Associate Professor

V

Voronka, Roman W., Professor Emeritus

W

Wang, Antai, Associate Professor

Y

Young, Yuan-Nan, Associate Professor

Z

Zaleski, Joseph, University Lecturer

Programs

- Applied Mathematics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-mathematics-ms/)
- Applied Statistics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistics-ms/)
- BioStatistics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/biostatistics-ms/)

- Mathematical and Computational Finance - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/mathematical-computational-finance-ms/)
- Mathematical Sciences - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/phd/)

Programs

- Applied Statistical Methods (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistical-methods-cert/)
- Biostatistics Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/biostatistics-essentials-cert/)
- Clinical Trials: Design and Analysis (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/clinical-trials_design-and-analysis-cert/)

Mathematical Sciences Courses

MATH 545. Introductory Mathematical Analysis. 3 credits, 3 contact hours.
Prerequisite: MATH 211 or MATH 213, and departmental approval. Rigorous treatment of the calculus of real-valued functions of one real variable: the real number system, epsilon-delta theory of limit, continuity, derivative, and the Riemann integral. The fundamental theory of calculus. Series and sequences including Taylor series and uniform convergence. The inverse and implicit function theorems.

MATH 546. Advanced Calculus. 3 credits, 3 contact hours.
Prerequisite: MATH 545 or MATH 480. Rigorous treatment of the calculus of real-valued functions of several real variables: the geometry and algebra of n-dimensional Euclidean space, limit, continuity, derivative, and the Riemann integral of functions of several variables, the inverse and implicit function theorems, series, including Taylor series, optimization problems, integration on curves and surfaces, the divergence and related theorems.

MATH 573. Intermediate Differential Equations. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 337, or departmental approval. Methods and applications for systems of ordinary differential equations: existence and uniqueness for solutions of ODEs, linear systems, stability analysis, phase plane and geometrical methods, Sturm-Liouville eigenvalue problems.

MATH 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisites: Graduate status, departmental approval, and permission of the Division of Career Development Services. Cooperative education/internship providing on-the-job complement to academic programs in mathematics. Work assignments and projects are developed by the Co-op Office in consultation with the Department of Mathematical Sciences.

MATH 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

MATH 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisites: Graduate status, departmental approval, and permission of the Division of Career Development Services.

MATH 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

MATH 599. Teaching in Mathematics. 3 credits, 3 contact hours.
Required of all master's and doctoral students in Mathematical Sciences who are receiving departmental or research-based awards. Provides students with the skills needed to communicate effectively and to perform their teaching and related duties. Students are exposed to strategies and methods for communicating and for teaching undergraduate mathematics, and they are required to practice and demonstrate these techniques. Not counted for degree credit.

MATH 604. Mathematical Finance. 3 credits, 3 contact hours.
Prerequisites: FIN 641 Derivatives, MATH 605 Stochastic Calculus, or permission of the instructor. This course will explore the structure, analysis, and use of financial derivative instruments deployed in investment strategies and portfolio risk management. Topics include continuous time dynamics, arbitrage pricing, martingale methods, and valuation of European, American, and path dependent derivatives.

MATH 605. Stochastic Calculus. 3 credits, 3 contact hours.
This course provides an introduction to stochastic calculus. Topics include conditioning, Poisson processes, martingales, Brownian motion, Ito integrals, Ito's formula, stochastic differential equations, Feynman-Kac formula, Girsanov's theorem, and the martingale representation theorem. Financial applications include pricing, hedging, and interest rate models.

MATH 606. Term Structure Models. 3 credits, 3 contact hours.
Prerequisites: MATH 605, or permission of the instructor. Corequisite: MATH 608. This course will develop the mathematical structure of interest rate models and explore the considerable hurdles involved in practical implementation. Short rate models, single and multifactor; the Heath-Jarrow-Morton framework; and modern Libor market models will be examined.

MATH 607. Credit Risk Models. 3 credits, 3 contact hours.
Prerequisites: MATH 604, MATH 605, MATH 606 or permission of the instructor. This course explores mathematical models and methods for credit risk measurement and rating. The nature of credit risk is reviewed through examination of credit instruments, including credit default swaps, collateralized debt obligations, and basket credit derivatives. These instruments, through which risk exposure opportunities and hedging possibilities are created and managed, are explored with respect to dynamics and valuation techniques, applying PDE methods and stochastic processes.

MATH 608. Partial Differential Equations for Finance. 3 credits, 3 contact hours.
This course presents the subject of partial differential equations (PDE's) with a strong emphasis on the PDE's arising in the study of stochastic processes and finance. The focus is on analytical and numerical methods for obtaining solutions in a form useful for solving problems in financial engineering. Topics include modeling with PDE's, classification of PDE's, analytical and numerical methods for PDE's and application to finance.

MATH 609. Projects in Mathematical and Computational Finance. 3 credits, 3 contact hours.
Prerequisites: MATH 604 Mathematical Finance, MATH 605 Stochastic Calculus, MATH 606 Term Structure Models, or permission of the instructor. This project course requires students to demonstrate attained mastery of the material studies in the prerequisite courses. Projects also extend students? knowledge of specific areas beyond that covered in earlier courses into areas such as particle filtering or optimization techniques for term structure model calibration. The aim is to broaden the students? classroom focus to the more unconstrained, open ended and less well defined contexts that are frequently encountered in practice.

MATH 610. Graduate Research Methods. 3 credits, 0 contact hours.
Prerequisites: MATH 614, MATH 671, and MATH 690. Acquaints second-year graduate students with the techniques and vocabulary of a field in applied mathematics. Each student contacts a designated faculty member and is given several basic papers or books on a research topic of current interest. The student prepares two lectures on his/her topic to be given at the end of the semester. A sample list of active fields of research includes acoustics, electromagnetic theory, elasticity, fluid dynamics, combustion, and mathematical biology.

MATH 611. Numerical Methods for Computation. 3 credits, 3 contact hours.
This course provides a practical introduction to numerical methods. Numerical solution of linear systems. Interpolation and quadrature. Interative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial and boundary value problems for ODE's. Introduction to numerical solution of PDE's. Applicatons drawn from science, engineering, and finance.

MATH 613. Advanced Applied Mathematics I: Modeling. 3 credits, 3 contact hours.
Prerequisites: MATH 331 and MATH 337, or departmental approval. Concepts and strategies of mathematical modeling are developed by investigation of case studies in a selection of areas. Consistency of a model, nondimensionalization and scaling, regular and singular effects are discussed. Possible topics include continuum mechanics (heat and mass transfer, fluid dynamics, elasticity), vibrating strings, population dynamics, traffic flow, and the Sommerfeld problem.

MATH 614. Numerical Methods I. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 337, MATH 340, and proficiency in a computer language (FORTRAN, C, or C++), or departmental approval. Theory and techniques of scientific computation, with more emphasis on accuracy and rigor than MATH 611. Machine arithmetic. Numerical solution of a linear system and pivoting. Interpolation and quadrature. Iterative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial- and boundary-value problems for systems of ODEs. Applications. The class includes examples requiring student use of a computer.

MATH 615. Approaches to Quantitative Analysis in the Life Sciences. 3 credits, 3 contact hours.
A graduate seminar-style course based around case studies of common data analytic methods used in the life sciences. The case studies are designed to help students who are interested in applications of statistical thinking to biological sciences appreciate the scope of quantitative methods, their underlying concepts, assumptions and limitations. While the mathematics of specific methods are not covered, students of the course will get an understanding of the diverse approaches to statistical inference in the life sciences.

MATH 630. Linear Algebra and Applications. 3 credits, 3 contact hours.
Prerequisites: (This course is not intended for students in the Master's in Applied Mathematics program or in the doctoral program in Mathematical Sciences.) Math 211 or Math 213, and Math 222. Development of the concepts needed to study applications of linear algebra and matrix theory to science and engineering. Topics include linear systems of equations, matrix algebra, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition.

MATH 631. Linear Algebra. 3 credits, 3 contact hours.
Prerequisites: MATH 222 and MATH 337, or departmental approval. Similar in aim and content to MATH 630 but with more emphasis on mathematical rigor. Linear systems of equations, matrix algebra, linear spaces, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition. Applications.

MATH 635. Analytical Computational Neuroscience. 3 credits, 3 contact hours.
Prerequisites: MATH 211 or 213, MATH 337, and CS 113 or MATH 240, or departmental approval. This course will provide an intermediate-level mathematical and computational modeling background for small neuronal systems. Models of biophysical mechanisms of single and small networks of neurons are discussed. Topics include voltage-dependent channel gating mechanisms, the Hodgkin-Huxley model for membrane excitability, repetitive and burst firing, single- and multi-compartmental modeling, synaptic transmission, mathematical treatment of 2-cell inhibitory or excitatory networks.
In this course, the students will be required to build computer models of neurons and networks and analyze these models using geometric singular-perturbation analysis and dynamical systems techniques.

MATH 636. Systems Computational Neuroscience. 3 credits, 3 contact hours.
Prerequisite: MATH 635. This course covers mathematical and computational modeling of neuronal networks. Topics covered include central pattern generators, models of visual processes, models of learning and memory, neural coding and mathematics of neural networks, models of oscillations in sensory, thalamic and thalamo-cortical networks, neuronal wave propagation.

MATH 637. Foundations of Mathematical Biology. 3 credits, 3 contact hours.
Prerequisites: MATH 222 and MATH 337, or departmental approval. This course provides an introduction to the use of mathematical techniques applied to solve problems in biology. Models discussed fall into 3 categories: discrete, continuous, and spatially distributed. Biological topics discussed range from the subcellular molecular systems and cellular behavior to physiological problems, population biology and developmental biology.

MATH 639. Mathematical Modeling II. 3 credits, 3 contact hours.
Continuation of MATH 613 (Advanced Applied Mathematics I, Modeling). Concepts and strategies of Mathematical modeling are developed by case studies in a selection of areas. Topics will be complementary to those presented in MATH 613, and include for example, the mathematical theory of elasticity and electromagnetism.

MATH 644. Regression Analysis Methods. 3 credits, 3 contact hours.
Prerequisite: MATH 661. Regression models and the least squares criterion. Simple and multiple linear regression. Regression diagnostics. Confidence intervals and tests of parameters, regression and analysis of variance. Variable selection and model building. Dummy variables and transformations, growth models. Other regression models such as logistic regression. Using statistical software for regression analysis.

MATH 645. Analysis I. 3 credits, 3 contact hours.
Prerequisite: MATH 546 or departmental approval. Review and extension of the fundamental concepts of advanced calculus: the real number system, limit, continuity, differentiation, the Riemann integral, sequences and series. Point set topology in metric spaces. Uniform convergence and its applications.

MATH 646. Time Series Analysis. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or departmental approval. Time series models, smoothing, trend and removal of seasonality. Naive forecasting models, stationarity and ARMA models. Estimation and forecasting for ARMA models. Estimation, model selection, and forecasting of nonseasonal and seasonal ARIMA models.

MATH 647. Time Series Analysis II. 3 credits, 3 contact hours.
Prerequisite: MATH 646. Continuation of MATH 646. Covers methods of time series analysis useful in engineering, the sciences, economics, and modern financial analysis. Topics include spectral analysis, transfer functions, multivariate models, state space models and Kalman filtering. Selected applications from topics such as intervention analysis, neural networks, process control, financial volatility analysis.

MATH 651. Methods of Applied Mathematics I. 3 credits, 3 contact hours.
Prerequisite: MATH 222 or departmental approval. A survey of mathematical methods for the solution of problems in the applied sciences and engineering. Topics include: ordinary differential equations and elementary partial differential equations. Fourier series, Fourier and Laplace transforms, and eigenfunction expansions.

MATH 654. Clinical Trials Design and Analysis. 3 credits, 3 contact hours.
Prerequisites: MATH 665 or equivalent with Departmental approval. Statistical methods and issues in the design of clinical trials and analysis of their data. Topic include clinical trial designs for phases 1-4, randomization principle and procedures, analysis of pharmacokinetic data for bioequivalence, multi-center trials, categorical data analysis, survival analysis, longitudinal data analysis, interim analysis, estimation of sample size and power, adjustment for multiplicity, evaluation of adverse events, and regulatory overview.

MATH 656. Complex Variables I. 3 credits, 3 contact hours.
Prerequisite: MATH 545 or MATH 645 or departmental approval. The theory and applications of analytic functions of one complex variable: elementary properties of complex numbers, analytic functions, elementary complex functions, conformal mapping, Cauchy integral formula, maximum modulus principle, Laurent series, classification of isolated singularities, residue theorem, and applications.

MATH 659. Survival Analysis. 3 credits, 3 contact hours.
Prerequisites: MATH 665 or equivalent with Departmental approval. Introduction to statistical methods for modeling time-to-event data in the presence of censoring and truncation, with emphasis on applications to the health sciences. Topics include survival and hazard functions, censoring and truncation, parametric and nonparametric models for survival data, competing-risks, regression models including Cox proportional hazards model and time-dependent covariates, one and two sample tests, and use of appropriate statistical software for computations.

MATH 660. Introduction to statistical Computing with SAS and R. 3 credits, 3 contact hours.
Prerequisite: Basic knowledge in statistical concepts or instructor approval. This course will study SAS and R programming and emphasize the SAS and R data steps including getting data into the SAS and R environments, working and combining data using control flows, merge and subsets, etc. as well as learning to export data and to generate high resolution graphics. Several SAS and R statistical procedures or functions will also be discussed and illustrated. Finally, interactive statistical software JMP and Minitab are briefly introduced.

MATH 661. Applied Statistics. 3 credits, 3 contact hours.
Prerequisite: MATH 112. Role and purpose of applied statistics. Data visualization and use of statistical software used in course. Descriptive statistics, summary measures for quantitative and qualitative data, data displays. Modeling random behavior: elementary probability and some simple probability distribution models. Normal distribution. Computational statistical inference: confidence intervals and tests for means, variances, and proportions. Linear regression analysis and inference. Control charts for statistical quality control. Introduction to design of experiments and ANOVA, simple factorial design and their analysis. MATH 661 and MATH 663 cannot both be used toward degree credits at NJIT.

MATH 662. Probability Distributions. 3 credits, 3 contact hours.
Prerequisites: MATH 341 or MATH 333, and departmental approval. Probability, conditional probability, random variables and distributions, independence, expectation, moment generating functions, useful parametric families of distributions, transformation of random variables, order statistics, sampling distributions under normality, the central limit theorem, convergence concepts and illustrative applications.

MATH 663. Introduction to Biostatistics. 3 credits, 3 contact hours.
Prerequisite: Undergraduate Calculus. Introduction to statistical techniques with emphasis on applications in health related sciences. This course will be accompanied by examples from biological, medical and clinical applications. Summarizing and displaying data; basic probability and inference; Bayes' theorem and its application in diagonostic testing; estimation, confidence intervals, and hypothesis testing for means and proportions; contingency tables; regression and analysis of variance; logistic regression and survival analysis; basic epidemiologic tools; use of statistical software. Math 661 and Math 663 cannot both be used toward degree credits at NJIT.

MATH 664. Methods for Statistical Consulting. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or departmental approval. Communicating with scientists in other disciplines. Statistical tools for consulting. Using statistical software such as JMP, SAS, and S-plus. Case studies which illustrate using statistical methodology and tools are presented by the instructor and guest speakers from academia and industry. Assignments based on case studies with use of statistical software is required.

MATH 665. Statistical Inference. 3 credits, 3 contact hours.
Prerequisite: MATH 662 or departmental approval. Review of sampling distributions. Data reduction principles: sufficiency and likelihood. Theory and methods of point estimation and hypothesis testing, interval estimation, nonparametric tests, introduction to linear models.

MATH 666. Simulation for Finance. 3 credits, 3 contact hours.
Covers the use of Monte Carlo stochastic simulation for finance applications. Topics include generation of various random variables and stochastic processes (e.g., point processes, Brownian motion, diffusions), simulation methods for estimating quantities of interest (e.g., option prices, probabilities, expected values, quantiles), input modeling, and variance-reduction techniques. Students will write computer programs in C++. Students cannot receive credit for both CS 661 and CS/MATH 666.

MATH 671. Asymptotic Methods I. 3 credits, 3 contact hours.
Prerequisites: MATH 645 or MATH 545, and MATH 656, or departmental approval. Asymptotic sequences and series. Use of asymptotic series. Regular and singular perturbation methods. Asymptotic methods for the solution of ODEs, including: boundary layer methods and asymptotic matching, multiple scales, the method of averaging, and simple WKB theory. Asymptotic expansion of integrals, including: Watson's lemma, stationary phase, Laplace's method, and the method of steepest descent.

MATH 672. Biomathematics I: Biological Waves and Oscillations. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 331, and MATH 337, or departmental approval. Models of wave propagation and oscillatory phenomena in nerve, muscle, and arteries: Hodgkin-Huxley theory of nerve conduction, synchronization of the cardiac pacemaker, conduction and rhythm abnormalities of the heart, excitation-contraction coupling, and calcium induced waves, wave propagation in elastic arteries, models of periodic human locomotion.

MATH 673. Biomathematics II: Pattern Formation in Biological Systems. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 331, and MATH 337, or departmental approval. Emergence of spatial and temporal order in biological and ecological systems: Hopf and Turing bifurcation in reaction-diffusion systems, how do zebras get their stripes, patterns on snake skins and butterfly wings, spatial organization in the visual cortex, symmetry breaking in hormonal interactions, how do the ovaries count. Basic techniques of mathematics are introduced and applied to significant biological phenomena that cannot be fully understood without their use.

MATH 675. Partial Differential Equations. 3 credits, 3 contact hours.
Prerequisite: MATH 690 or departmental approval. A survey of the mathematical theory of partial differential equations: first-order equations, classification of second-order equations, the Cauchy-Kovalevsky theorem, properties of harmonic functions, the Dirichlet principle. Initial- and boundary-value problems for hyperbolic, elliptic, and parabolic equations. Systems of equations.

MATH 676. Advanced Ordinary Differential Equations. 3 credits, 3 contact hours.
Prerequisites: MATH 222, MATH 337, and MATH 545 or MATH 645. A rigorous treatment of the theory of systems of differential equations: existence and uniqueness of solutions, dependence on initial conditions and parameters. Linear systems, stability, and asymptotic behavior of solutions. Nonlinear systems, perturbation of periodic solutions, and geometric theory of systems of ODEs.

MATH 677. Calculus of Variations. 3 credits, 3 contact hours.
Prerequisite: MATH 545 or MATH 645 or departmental approval. Necessary conditions for existence of extrema. Variation of a functional, Euler's equation, constrained extrema, first integrals, Hamilton-Jacobi equation, quadratic functionals. Sufficient conditions for the existence of extrema. Applications to mechanics.

MATH 678. Stat Methods in Data Science. 3 credits, 3 contact hours.
Prerequisite: MATH 661 or MATH 663, or permission by instructor. This course introduces students to concepts in statistical methods used in data science, including data collection, data visualization and data analysis. Emphasis is on model building and statistical concepts related to data analysis methods. The course provides the basic foundational tools on which to pursue statistics, data analysis and data science in greater depth. Topics include sampling and experimental design, understanding the aims of a study, principles of data analysis, linear and logistic regression, resampling methods, and statistical learning methods. Students will use the R statistical software.

MATH 680. Advanced Statistical Learning. 3 credits, 3 contact hours.
Prerequisites: MATH 478 or MATH 678, or permission by instructor. This course builds on the material in MATH 478 or MATH 678 and serves as a second graduate course in data science with emphasis on statistics. It covers many topics in high dimensional data analysis, including LASSO, SCAD and other regularization procedures, sparse PCA, sparse k-means, and asymptotic theory for high dimensional models. This course will provide students with necessary theoretical and computational skills to understand, design, and implement modern statistical learning methods, including ensemble learning (bagging, random forest, and boosting). Students will use the R statistical software.

MATH 683. High Dimensional Stat Inferenc. 3 credits, 3 contact hours.
Prerequisite: MATH 665 or permission by instructor. This course introduces modern statistical inference theory and methods developed as a result of the influence of computing. The course covers statistical thinking, ideas and theory that underlie many of the statistical learning algorithms used in data science, such as bootstrap, EM algorithm, cross-validation, large-scale hypothesis test, false discovery rates, sparse modeling, support vector machines and ensemble learning.

MATH 687. Quantitative Analysis for Environmental Design Research. 3 credits, 3 contact hours.
Prerequisites: MATH 333 and departmental approval. Fundamental concepts in the theory of probability and statistics including descriptive data analysis, inferential statistics, sampling theory, linear regression and correlation, and analysis of variance. Also includes an introduction to linear programming and nonlinear models concluding with some discussion of optimization theory.

MATH 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
Prerequisites: MATH 111, MATH 112 and (MATH 211 or MATH 213). The course introduces mathematical methods necessary for materials science with emphasis on practical applications. Topics include power series, complex numbers, linear algebra, partial differentiation, multiple integrals, vector analysis, Fourier series and transformation, ordinary and partial differential equations, functions of complex variables, probability, and statistics.

MATH 689. Advanced Applied Mathematics II: Ordinary Differential Equations. 3 credits, 3 contact hours.
Prerequisites: MATH 545 or MATH 645, MATH 613, and MATH 631. A practical and theoretical treatment of boundary-value problems for ordinary differential equations: generalized functions, Green's functions, spectral theory, variational principles, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

MATH 690. Advanced Applied Mathematics III: Partial Differential Equations. 3 credits, 3 contact hours.
Prerequisite: MATH 689. A practical and theoretical treatment of initial- and boundary-value problems for partial differential equations: Green's functions, spectral theory, variational principles, transform methods, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

MATH 691. Stochastic Processes with Applications. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Renewal theory, renewal reward processes and applications. Homogeneous, non-homogeneous, and compound Poisson processes with illustrative applications. Introduction to Markov chains in discrete and continuous time with selected applications.

MATH 692. MSMCF Forum. 0 credits, 0 contact hours.
Forum comprises informal discussions and debates engaging students in the realities of living and working in the world, with a focus on economics and finance. These realities include broad awareness of contemporary events, ethical implications of decisions, proper implementation and use of models, the research process and the critical skills of communication. Forum meetings are designed to promote understanding and build experience in all these areas.

MATH 698. Sampling Theory. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Role of sample surveys. Sampling from finite populations. Sampling designs, the Horowitz-Thompson estimator of the population mean. Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.

MATH 699. Design and Analysis of Experiments. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Statistically designed experiments and their importance in data analysis, industrial experiments. Role of randomization. Fixed and random effect models and ANOVA, block design, latin square design, factorial and fractional factorial designs and their analysis.

MATH 700. Master's Project. 0 credits, 0 contact hours.
Prerequisites: Matriculation for the Master of Science in Applied Mathematics or in Applied Statistics and departmental approval. Work must be initiated with the approval of a faculty member, who will be the student's project advisor. Work of sufficient quality may qualify for extension into a master's thesis, see Math 701.

MATH 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied mathematics or applied statistics. A written report must be submitted to the project advisor. The student cannot register in MATH 700B more than once and the incomplete (I) grade is not allowed.

MATH 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: Matriculation for the master's degree and departmental approval. Students must register for a minimum of 3 credits per semester until completion. The work is carried out under the supervision of a designated member of the faculty.

MATH 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied mathematics or applied statistics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in MATH 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MATH 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied mathematics or applied statistics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (MATH 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MATH 707. Advanced Applied Mathematics IV: Special Topics. 3 credits, 3 contact hours.
Prerequisite: Departmental approval. A current research topic of interest to departmental faculty. Typical topics include: computational fluid dynamics, theoretical fluid dynamics, acoustics, wave propagation, dynamical systems, theoretical and numerical aspects of combustion, mathematical biology, and various topics in statistics.

MATH 712. Numerical Methods II. 3 credits, 3 contact hours.
Prerequisites: MATH 614, MATH 331 or departmental approval, and proficiency in a computer programming language (FORTRAN, C, or C++). Numerical methods for the solution of initial- and boundary-value problems for partial differential equations, with emphasis on finite difference methods. Consistency, stability, convergence, and implementation are considered.

MATH 713. Advanced Scientific Computing: Multi-Dimensional Finite-Difference Schemes and Spectral Methods. 3 credits, 3 contact hours.
Prerequisites: MATH 712 and proficiency in a computer programming language (FORTRAN, C, or C++). Derivation and analysis of finite difference schemes for systems of partial differential equations in two and three spatial dimensions and time. Issues pertaining to efficient implementation of algorithms and to stability of physical and numerical boundary conditions. Pseudo-spectral and spectral methods to solve partial differential equations. Approximation properties of Fourier and Chebyshev series and techniques based on the Fast Fourier Transform (FFT) and on matrix multiplication to numerically compute partial derivatives. Time-discretization techniques suitable for use with pseudo-spectral and spectral methods. Model systems arising in wave propagation, fluid dynamics, and mathematical biology will be considered.

MATH 715. Mathematical Fluid Dynamics I. 3 credits, 3 contact hours.
Introduction to the basic ideas of fluid dynamics, with an emphasis on rigorous treatment of fundamentals and the mathematical developments and issues. The course focuses on the background and motivation for recent mathematical and numerical work on the Euler and Navier-Stokes equations, and presents a mathematically intensive investigation of various model equations of fluid dynamics (e.g., the Korteweg-de-Vries equations).

MATH 716. Mathematical Fluid Dynamics II. 3 credits, 0 contact hours.
Continuation of MATH 715. Further development of the ideas of fluid dynamics, with an emphasis on mathematical developments and issues. A selection of topics will be developed in some detail, for example: Stokes flow and low-Reynolds-number hydrodynamics; flow at high Reynolds number and boundary layers; shock waves and hyperbolic systems; dynamics of interfacial flows; hydrodynamic stability; rotating fluids.

MATH 717. Inverse Problems and Global Optimization. 3 credits, 3 contact hours.
Introduction to inverse problems and global optimization. Linear, quasi-linear, and nonlinear inverse problems are studied with emphasis on regularization techniques. Bayesian statistical approaches and Monte Carlo methods are introduced and discussed in the context of inverse problems. The mathematical foundations of simulated annealing, genetic algorithms, and TABU are presented.

MATH 720. Tensor Analysis. 3 credits, 3 contact hours.
Prerequisites: MATH 613 and MATH 631, or departmental approval. Review of vector analysis in general curvilinear coordinates. Algebra and differential calculus of tensors. Applications to differential geometry, analytical mechanics, and mechanics of continuous media. The choice of applications will be determined by the interests of the class.

MATH 722. Wave Propagation. 3 credits, 3 contact hours.
Derivation of linear wave equations describing acoustic, electromagnetic, elastodynamic and hydrodynamic phenomena. Fundamental solutions and their application to initial value problems. Applications and solution of boundary value problems using Green's functions, image and spectral methods. Related time harmonic problems, including radiation, scattering, diffraction and transmission phenomena. Dispersive waves and the method of stationary phase. Linear waves in anisotropic media.

MATH 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

MATH 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for MATH 726 if they have taken MATH 725 in a prior semester.

MATH 745. Analysis II. 3 credits, 3 contact hours.
Prerequisite: MATH 645. Lebesgue measure and integration, including the Lebesgue dominated convergence theorem and Riesz-Fischer theorem. Elements of Hilbert spaces and Lp-spaces. Fourier series and harmonic analysis. Multivariate calculus.

MATH 756. Complex Variables II. 3 credits, 3 contact hours.
Prerequisite: MATH 656. Selected topics from: conformal mapping and applications of the Schwarz-Christoffel transformation, applications of calculus of residues, singularities, principle of the argument, Rouche's theorem, Mittag-Leffler's theorem, Casorati-Weierstrass theorem, analytic continuation, and applications, Schwarz reflection principle, monodromy theorem, Wiener-Hopf technique, asymptotic expansion of integrals; integral transform techniques, special functions.

MATH 761. Statistical Reliability Theory and Applications. 3 credits, 3 contact hours.
Prerequisite: MATH 662 or departmental approval. Survival distributions, failure rate and hazard functions, residual life. Common parametric families used in modeling life data. Introduction to nonparametric aging classes. Coherent structures, fault tree analysis, redundancy and standby systems, system availability, repairable systems, selected applications such as software reliability.

MATH 763. Generalized Linear Models. 3 credits, 3 contact hours.
Prerequisites: MATH 662 and MATH 665 or departmental approval. Theoretical and applied aspects of generalized linear models. Classical linear models, nonlinear regression models, and generalized estimating equations.

MATH 767. Fast Numerical Algorithms. 3 credits, 3 contact hours.
The course covers state-of-the-art, analysis-based, fast numerical algorithms for computing discrete summations/transforms and for solving differential/integral equations. In particular, this course presents fast multiple methods and their descendants, including fast Fourier transform for nonequispaced data, fast Gauss transform, fast iterative solver and direct solver for elliptic boundary value problems.

MATH 768. Probability Theory. 3 credits, 3 contact hours.
Prerequisite: MATH 645 or departmental approval. Measure theoretic introduction to axiomatic probability. Probability measures on abstract spaces and integration. Random variables and distribution functions, independence, 0-1 laws, basic inequalities, modes of convergence and their interrelationships, Laplace-Stieltjes transforms and characteristic functions, weak and strong laws of large numbers, conditional expectation, discrete time martingales.

MATH 771. Asymptotic Methods II. 3 credits, 3 contact hours.
Prerequisite: MATH 671. Continuation of MATH 671. Asymptotic methods for the solution of PDEs, including: matched asymptotic expansions, multiple scales, the WKB method or geometrical optics, and near-field far-field expansions. Applications to elliptic, parabolic, and hyperbolic problems. Further topics in the asymptotic expansion of integrals and the WKB method. Emphasis on examples drawn from applications in science and engineering.

MATH 786. Large Sample Theory and Inference. 3 credits, 3 contact hours.
Prerequisites: MATH 665 and MATH 768. Limit theorems, central limit theorem, asymptotic expansions and large deviations, limit theorems in martingales and semi-martingales and stochastic differential equations, asymptotic expansions of functions of statistics, linear parametric estimation, asymptotic efficiency, martingale approach to inference: test for homogeneity and goodness of fit, decomposable statistics, inference for counting processes and censored data, inference in nonlinear regression, existence and consistency of least squares estimator (LSE), asymptotic properties of LSE, Von Mises functionals, estimation of parameters of stable laws, empirical characteristics function for inference, generalized least squares for linear models.

MATH 787. Non-Parametric Statistics. 3 credits, 3 contact hours.
Prerequisite: MATH 662. Wilcoxon signed-ranks test, Mann-Whitney U test, binomial sign test for single sample and two dependent samples, McNemar's test, Cochran Q test, Wilcoxon matched-pairs signed-ranks test, Kruskal-Wallis one-way analysis of variance, Friedman two-way analysis of variance, Siegel-Tukey test for equal variability, chi-squared goodness-of-fit test, test for homogeneity and independence, single-sample runs test and other tests of randomness, correlation tests: Spearman's rank-order correlation, coefficient and Kendall's tau, Kendall's coefficient of concordance, and Goodman and Kruskal's gamma, comparing power efficiency.

MATH 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Prerequisite: Excellent performance on the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Candidates must register for 6 to12 credits per semester, to be determined by a designated dissertation advisor. After reaching 36 credits, students must continue to register for 3 credits each semester until degree completion.

MATH 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: MATH 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mathematical sciences. For PhD students who have successfully defended their dissertation proposal. The student must register in MATH 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

MATH 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: MATH 791. Since the MATH 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in mathematical sciences. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

MATH 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: MATH 791. Since the MATH 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in mathematical sciences. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

MATH 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.
Prerequisite: Excellent performance on the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Candidates must register for 6 to12 credits per semester, to be determined by a designated dissertation advisor. After reaching 36 credits, students must continue to register for 3 credits each semester until degree completion.

MATH 790E. Doctoral Dissertation. 12 credits, 12 contact hours.
Prerequisite: Excellent performance on the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Candidates must register for 6 to12 credits per semester, to be determined by a designated dissertation advisor. After reaching 36 credits, students must continue to register for 3 credits each semester until degree completion.

MATH 791. Graduate Seminar. 0 credits, 1 contact hour.
All master's and doctoral students receiving departmental or research-based awards must register for this course each semester.

MATH 792B. Pre Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: MATH 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in mathematical sciences. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

MATH 792D. Pre Doctoral Research. 9 credits, 9 contact hours.

Applied Statistical Methods

The Applied Statistical Methods Graduate Certificate provides professionals with advanced skills and tools to collect data, analyze it, and interpret results across a wide variety of high tech companies.

Who should enroll in this program?

This program is designed for data analysts, production engineers, financial analysts, information specialists, and technical supervisors.

What are the Required Courses?

Code	Title	Credits
Core Courses		
MATH 661	Applied Statistics	3
MATH 644	Regression Analysis Methods *	3
Electives		
Select two of the following:		6
MATH 698	Sampling Theory	
MATH 699	Design and Analysis of Experiments	
MATH 664	Methods for Statistical Consulting	
MATH 646	Time Series Analysis	

* indicates as available online

What will I learn?

How to collect data, how to analyze and summarize data and how to interpret the results. The techniques learned in this certificate can be applied to quality control, production design and analysis, telecommunications, financial analysis, and risk analysis. This certificate will help the data analysts in conducting appropriate statistical analyses of their data and helping the technical supervisors in understanding the results of statistical analyses conducted by other people.

- Role and purpose of applied statistics. Data visualization and use of statistical software used in course. Descriptive statistics, summary measures for quantitative and qualitative data, data displays. Modeling random behavior: elementary probability and some simple probability distribution models. Normal distribution. Computational statistical inference: confidence intervals and tests for means, variances, and proportions. Linear regression analysis and inference. Control charts for statistical quality control. Introduction to design of experiments and ANOVA, simple factorial design and their analysis.

- Regression models and the least squares criterion. Simple and multiple linear regression. Regression diagnostics. Confidence intervals and tests of parameters, regression and analysis of variance. Variable selection and model building. Dummy variables and transformations, growth models. Other regression models such as logistic regression. Using statistical software for regression analysis.
- Role of sample surveys. Sampling from finite populations. Sampling designs, the Horowitz-Thompson estimator of the population mean. Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.
- Statistically designed experiments and their importance in data analysis, industrial experiments. Role of randomization. Fixed and random effect models and ANOVA, block design, latin square design, factorial and fractional factorial designs and their analysis.
- Communicating with scientists in other disciplines. Statistical tools for consulting. Using statistical software such as JMP, SAS, and S-plus. Case studies which illustrate using statistical methodology and tools are presented by the instructor and guest speakers from academia and industry.
- Time series models, smoothing, trend and removal of seasonality. Naive forecasting models, stationarity and ARMA models. Estimation and forecasting for ARMA models. Estimation, model selection, and forecasting of nonseasonal and seasonal ARIMA models.

Why study Applied Statistical Methods at NJIT?

The graduate certificate’s narrow focus allows you to dig deep into this specific topic, and start applying your knowledge sooner. Earn this certificate on our NJIT Newark campus. And you’ll learn from NJIT’s distinguished professors and instructors.

Prerequisites

Applicants must have an undergraduate degree from an accredited institution with at least 12 credits in mathematics, including calculus. Students who do not meet these requirements may be admitted if they satisfy the university's requirements for admission. An undergraduate GPA of at least 3.0 on a 4.0 scale or equivalent is normally required.

Related Degree Programs

All credits for the Applied Statistical Methods Certificate relates in its entirety to NJIT MS in Applied Statistics (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/applied-statistics-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/applied-statistical-methods-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Ji Meng Loh (http://directory.njit.edu/PersDetails.aspx?persid=loh)

Biostatistics Essentials

The Graduate Certificate in Biostatistics Essentials provides the groundworks for developing new statistical methods, as well as applying existing techniques, to interpret data about the medical and life sciences. Biostatistics is important because it is used widely in the pharmaceutical industry, the health-care industry and in medical schools.

What kind of jobs do biostatisticians have?

Most biostatisticians work in a university, a healthcare field, a research institution or pharmaceutical firm. By using sophisticated software and statistical methods, they study the factors that affect human health. They also provide advice on how to use statistics to design and analyze studies.

What are the Required Courses?

Code	Title	Credits
Core Courses		
MATH 663	Introduction to Biostatistics	3
MATH 662	Probability Distributions	3
Electives		
Select two of the following:		6
MATH 664	Methods for Statistical Consulting	
MATH 665	Statistical Inference	
MATH 654	Clinical Trials Design and Analysis	
MATH 659	Survival Analysis	

What will I learn?

- Statistical techniques with emphasis on applications in health related sciences, summarizing and displaying data; basic probability and inference; Bayes' theorem and its application in diagonostic testing; estimation, confidence intervals, and hypothesis testing for means and proportions;

contingency tables; regression and analysis of variance; logistic regression and survival analysis; basic epidemiologic tools; use of statistical software.
- Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.
- Statistical methods and issues in the design of clinical trials and analysis of their data, which include clinical trial designs for phases 1-4, randomization principle and procedures, analysis of pharmacokinetic data for bioequivalence, multi-center trials, categorical data analysis, survival analysis, longitudinal data analysis, interim analysis, estimation of sample size and power, adjustment for multiplicity, evaluation of adverse events, and regulatory overview.
- Modeling time-to-event data in the presence of censoring and truncation, with emphasis on applications to the health sciences, including survival and hazard functions, censoring and truncation, parametric and nonparametric models for survival data, competing-risks, regression models including Cox proportional hazards model and time-dependent covariates, one and two sample tests, and use of appropriate statistical software for computations.

Why study Biostatistics Essentials at NJIT?

The certificate allows the students to focus and dig deep into this specific topic, and start applying your knowledge sooner. Earn this certificate on our NJIT Newark campus. And you'll learn from NJIT's distinguished professors and instructors.

Prerequisites

Applicants must have an undergraduate degree from an accredited institution with at least 12 credits in mathematics, including calculus. Students who do not meet these requirements may be admitted if they satisfy the university's requirements for admission. An undergraduate GPA of at least 3.0 on a 4.0 scale or equivalent is normally required.

Related Degree Programs

All credits for the Biostatistics Essentials Graduate Certificate relate in their entirety to NJIT MS in Biostatistics (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/mathematical-sciences/biostatistics-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/biostatistics-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Sundarraman Subramanian (http://directory.njit.edu/PersDetails.aspx?persid=sundars)

CLINICAL TRIALS: DESIGN AND ANALYSIS

The Graduate Certificate in Clinical Trials: Design and Analysis is a short, but dense, selection of statistical courses from NJIT's Department of Mathematical Sciences. Topics will include: probability theory, binomial distribution, regression analysis, standard deviation, stochastic processes, Monte Carlo method, Bayesian statistics, non-parametric statistics, sampling theory, and statistical techniques. The theoretical approach that begins the program comes together within the elective courses in a practical sense, from pharmokinetic data to life science studies to business-oriented time series data sets.

Who would be suited to take this program?

The program is well suited for students with a baccalaureate degree, especially with higher level Calculus background, who are planning to pursue a statistics-oriented career in the pharmaceutical or other industries and in commercial enterprises where basic statistical skills and knowledge of contemporary methods of data analysis and modeling are required, such as computational data analytic or business intelligence positions.

What are the Required Courses?

Code	Title	Credits
Core Courses		
Take this course:		3
MATH 662 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 662)	Probability Distributions	
Electives - Choose three (3) courses:		9
MATH 615 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 615)	Approaches to Quantitative Analysis in the Life Sciences	

MATH 654 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 654)	Clinical Trials Design and Analysis
MATH 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 665)	Statistical Inference
MATH 698 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 698)	Sampling Theory
MATH 699 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 699)	Design and Analysis of Experiments

What will I learn?

- ***Probability Distributions* -** Probability, conditional probability, random variables and distributions, independence, expectation, moment generating functions, useful parametric families of distributions, transformation of random variables, order statistics, sampling distributions under normality, the central limit theorem, convergence concepts and illustrative applications.
- ***Approaches to Quantitative Analysis in the Life Sciences* -** Case studies of common data analytic methods used in the life sciences. The case studies are designed to help students who are interested in applications of statistical thinking to biological sciences appreciate the scope of quantitative methods, their underlying concepts, assumptions and limitations.
- ***Clinical Trials Design and Analysis* -** Statistical methods and issues in the design of clinical trials and analysis of their data. Topic include clinical trial designs for phases 1-4, randomization principle and procedures, analysis of pharmacokinetic data for bioequivalence, multi-center trials, categorical data analysis, survival analysis, longitudinal data analysis, interim analysis, estimation of sample size and power, adjustment for multiplicity, evaluation of adverse events, and regulatory overview.
- ***Statistical Inference* -** Data reduction principles: sufficiency and likelihood. Theory and methods of point estimation and hypothesis testing, interval estimation, nonparametric tests, introduction to linear models.
- ***Sampling Theory* -** Role of sample surveys. Sampling from finite populations. Sampling designs, the Horowitz-Thompson estimator of the population mean. Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.
- ***Design and Analysis of Experiments* -** Statistically designed experiments and their importance in data analysis, industrial experiments. Role of randomization. Fixed and random effect models and ANOVA, block design, latin square design, factorial and fractional factorial designs and their analysis.

Why study Clinical Trials: Design and Analysis at NJIT?

The NJIT Department of Mathematics offers two types of courses: theoretical and practical. Graduates from this program will understand the concepts of advanced statistical techniques as well as modern day software that utilize these concepts.

Into what industries might holders of this program find employment?

Data Science, Consultation Services, Auditing, Analytics, Census

Prerequisites

Applicants should have a bachelor's degree in an engineering or mathematics-based field. Undergraduate statistics coursework and Calculus III+ expected.

Related Degree Programs

All courses in this program related entirely to the NJIT MS in Applied Statistics (https://catalog.njit.edu/graduate/science-liberal-arts/mathematical-sciences/applied-statistics-ms/)

Faculty Advisor: Sunil Dhar (https://math.njit.edu/faculty/dhar/)

M.S. in Applied Mathematics

Degree Requirements

Students with a baccalaureate degree in an area different from mathematics may be admitted and required by the department to take an individually-designed program of bridge courses that may include undergraduate courses before proceeding to the graduate curriculum. Such courses do not count towards a graduate degree.

The Master of Science in Applied Mathematics requires 30 credits: 15 credits in core courses, 15 credits in an area of specialization, of which six credits are required and nine credits are electives. Students must successfully complete at least 24 of these credits at the 600-level or higher, and no more than six credits at the 500-level will be counted towards the degree. Specific course requirements depend on the area of specialization. A master's thesis or a master's project is optional. (Advisor's permission is required)

Seminar: In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll every semester in MATH 791 Graduate Seminar.

M.S. in Applied Mathematics (courses only)

Code	Title	Credits
Core Courses		
MATH 613	Advanced Applied Mathematics I: Modeling	3
MATH 631	Linear Algebra	3
MATH 645	Analysis I [1]	3
MATH 656	Complex Variables I	3
MATH 689	Advanced Applied Mathematics II: Ordinary Differential Equations	3
Required Courses in Areas of Specialization		
Select one of the following Areas of Specialization:		6
Analysis		
MATH 745	Analysis II	
MATH 756	Complex Variables II	
Applied Mathematics		
MATH 614	Numerical Methods I	
MATH 690	Advanced Applied Mathematics III: Partial Differential Equations	
Computational Mathematics		
MATH 614	Numerical Methods I	
MATH 712	Numerical Methods II	
Mathematical Biology		
MATH 635	Analytical Computational Neuroscience	
MATH 637	Foundations of Mathematical Biology	
Electives		
Select three courses with approval of graduate advisor		9
Total Credits		30

1 Students specializing in Applied Mathematics or Computational Mathematics may take MATH 545 Introductory Mathematical Analysis and MATH 546 Advanced Calculus, instead of MATH 645 Analysis I and 3 credits of elective.

M.S. in Applied Mathematics (Master's project)

Code	Title	Credits
Core Courses		
MATH 613	Advanced Applied Mathematics I: Modeling	3
MATH 631	Linear Algebra	3
MATH 645	Analysis I [1]	3
MATH 656	Complex Variables I	3
MATH 689	Advanced Applied Mathematics II: Ordinary Differential Equations	3
Project		
MATH 700B	Master's Project	3

Required Courses in Areas of Specialization		
Select one of the following Areas of Specialization:		6
Analysis		
MATH 745	Analysis II	
MATH 756	Complex Variables II	
Applied Mathematics		
MATH 614	Numerical Methods I	
MATH 690	Advanced Applied Mathematics III: Partial Differential Equations	
Computational Mathematics		
MATH 614	Numerical Methods I	
MATH 712	Numerical Methods II	
Mathematical Biology		
MATH 635	Analytical Computational Neuroscience	
MATH 637	Foundations of Mathematical Biology	
Electives		
Select three courses with approval of graduate advisor.		9
Total Credits		33

1 Students specializing in Applied Mathematics or Computational Mathematics may take MATH 545 Introductory Mathematical Analysis and MATH 546 Advanced Calculus, instead of MATH 645 Analysis I and 3 credits of elective.

M.S. in Applied Mathematics (Master's thesis)

Code	Title	Credits
Core Courses		
MATH 613	Advanced Applied Mathematics I: Modeling	3
MATH 631	Linear Algebra	3
MATH 645	Analysis I [1]	3
MATH 656	Complex Variables I	3
MATH 689	Advanced Applied Mathematics II: Ordinary Differential Equations	3
Thesis		
Required Courses in Areas of Specialization		
MATH 701B & 701B	Master's Thesis and Master's Thesis	6
or MATH 701C	Master's Thesis	
Select one of the following Areas of Specialization:		6
Analysis		
MATH 745	Analysis II	
MATH 756	Complex Variables II	
Applied Mathematics		
MATH 614	Numerical Methods I	
MATH 690	Advanced Applied Mathematics III: Partial Differential Equations	
Computational Mathematics		
MATH 614	Numerical Methods I	
MATH 712	Numerical Methods II	
Mathematical Biology		
MATH 635	Analytical Computational Neuroscience	
MATH 637	Foundations of Mathematical Biology	
Electives		
Select three courses with approval of graduate advisor.		9
Total Credits		36

1 Students specializing in Applied Mathematics or Computational Mathematics may take MATH 545 Introductory Mathematical Analysis and MATH 546 Advanced Calculus, instead of MATH 645 Analysis I and 3 credits of elective.

Electives are chosen in consultation with a Departmental Graduate Advisor and consist of advanced courses in mathematics and advanced courses from biology, physics, computer science, and engineering, for example. Courses offered by appropriate departments at NJIT, RBHS, and Rutgers-Newark can be used as electives within the limits of the NJIT transfer policy. All elective courses must be approved by the graduate advisor.

M.S. in Applied Statistics

Degree Requirements

The Master of Science in Applied Statistics requires 30 credits: 21 credits in core courses and 9 credits of elective courses. Students must successfully complete at least 24 of these credits at the 600-level or higher, and no more than six credits at the 500-level will be counted towards the degree. A master's thesis or a master's project is optional.

Seminar: In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll every semester in MATH 791 Graduate Seminar.

M.S. in Applied Statistics (courses only)

Code	Title	Credits
Core Courses		
MATH 611	Numerical Methods for Computation	3
or MATH 630	Linear Algebra and Applications	
MATH 644	Regression Analysis Methods	3
MATH 661	Applied Statistics [1]	3
MATH 662	Probability Distributions	3
MATH 664	Methods for Statistical Consulting	3
MATH 665	Statistical Inference	3
MATH 699	Design and Analysis of Experiments	3
Electives		
Select three courses with approval of graduate advisor		9
Total Credits		30

1 MATH 661 Applied Statistics and MATH 663 Introduction to Biostatistics cannot both be used toward degree credits at NJIT. The requirements of MATH 661 Applied Statistics may, in individual cases, be substituted by MATH 663 Introduction to Biostatistics, at the discretion of the Graduate Advisor.

M.S. in Applied Statistics (M.S. project)

Code	Title	Credits
Core Courses		
MATH 611	Numerical Methods for Computation	3
or MATH 630	Linear Algebra and Applications	
MATH 644	Regression Analysis Methods	3
MATH 661	Applied Statistics [1]	3
MATH 662	Probability Distributions	3
MATH 664	Methods for Statistical Consulting	3
MATH 665	Statistical Inference	3
MATH 699	Design and Analysis of Experiments	3
Master's Project		
MATH 700B	Master's Project	3
Electives		
Select two courses with approval of graduate advisor		6
Total Credits		30

1 MATH 661 Applied Statistics and MATH 663 Introduction to Biostatistics cannot both be used toward degree credits at NJIT. The requirements of MATH 661 Applied Statistics may, in individual cases, be substituted by MATH 663 Introduction to Biostatistics, at the discretion of the Graduate Advisor.

M.S. in Applied Statistics (M.S. thesis)

Code	Title	Credits
Core Courses		
MATH 611	Numerical Methods for Computation	3
or MATH 630	Linear Algebra and Applications	
MATH 644	Regression Analysis Methods	3
MATH 661	Applied Statistics [1]	3
MATH 662	Probability Distributions	3
MATH 664	Methods for Statistical Consulting	3
MATH 665	Statistical Inference	3
MATH 699	Design and Analysis of Experiments	3
Master's Thesis		
MATH 701B & 701B	Master's Thesis and Master's Thesis	6
or MATH 701C	Master's Thesis	
Electives		
Select one course with approval of graduate advisor		3
Total Credits		30

[1] MATH 661 Applied Statistics and MATH 663 Introduction to Biostatistics cannot both be used toward degree credits at NJIT. The requirements of MATH 661 Applied Statistics may, in individual cases, be substituted by MATH 663 Introduction to Biostatistics, at the discretion of the Graduate Advisor.

Electives are chosen in consultation with a departmental graduate advisor and consist of advanced courses in mathematics and statistics and advanced courses from engineering, computer science, and biology that have a significant statistics content. Students are encouraged to choose courses in application areas. Courses offered by appropriate departments at NJIT, RBHS, and Rutgers University-Newark can be used as electives within the limits of the NJIT transfer policy. All elective courses must be approved by the graduate advisor.

M.S. in Biostatistics

Degree Requirements

A minimum of 30 credits is required for the degree. Bridge courses, if any, will not count toward degree credits. The graduate curriculum consists of seven core courses in background statistical theory and biostatistics, as described in the curriculum below. The remaining courses are electives, chosen in consultation with a departmental graduate advisor and consist of topics courses in statistics, biostatistics, epidemiology and biology that have significant statistics content or/and applications thereof. Students will be encouraged to choose courses in application areas. Courses offered by appropriate departments at NJIT, RBHS, and Rutgers University-Newark can be used as electives within the limits of the NJIT transfer policy. A masters project is optional, and is in addition to the minimum 30 approved credits, required for the degree.

Code	Title	Credits
Core Courses		
MATH 644	Regression Analysis Methods	3
MATH 654	Clinical Trials Design and Analysis	3
MATH 659	Survival Analysis	3
MATH 662	Probability Distributions	3
MATH 663	Introduction to Biostatistics [1]	3
MATH 665	Statistical Inference	3
MATH 699	Design and Analysis of Experiments	3
Electives		
Select at least three of the following illustrative list:		9
MATH 664	Methods for Statistical Consulting	
MATH 691	Stochastic Processes with Applications	
MATH 698	Sampling Theory	
MATH 707	Advanced Applied Mathematics IV: Special Topics (Advanced Applied Mathematics IV)	
MATH 763	Generalized Linear Models	
MATH 786	Large Sample Theory and Inference	

MATH 787	Non-Parametric Statistics	
RBHS	RBHS Courses	
Introduction to Epidemiology		
Total Credits		30

[1] MATH 661 Applied Statistics and MATH 663 Introduction to Biostatistics cannot both be used toward degree credits at NJIT. The requirements of MATH 663 Introduction to Biostatistics may, in individual cases, be substituted by MATH 661 Applied Statistics, at the discretion of the Graduate Advisor.

M.S. in Mathematical and Computational Finance

Degree Requirements

Master of Science in Mathematical and Computational Finance

The Master of Science in Mathematical and Computational Finance requires 33 credits: 27 credits in core courses, 3 credits in an approved elective, and 3 credits in a project course.

Course	Title	Credits
Semester I		
FIN 641	Derivatives Markets	3
MATH 605	Stochastic Calculus	3
MATH 611	Numerical Methods for Computation	3
MATH 646	Time Series Analysis	3
	Term Credits	12
Semester II		
MATH 604	Mathematical Finance	3
MATH 606	Term Structure Models	3
MATH 608	Partial Differential Equations for Finance	3
CS 666 or MATH 666	Simulation for Finance or Simulation for Finance	3
	Term Credits	12
Semester III		
MATH 607	Credit Risk Models	3
Approved Elective		3
MATH 609	Projects in Mathematical and Computational Finance	3
	Term Credits	9
	Total Credits	33

For students having already successfully completed the equivalent of a course required for the program, more advanced courses can be substituted with departmental approval.

Electives

Code	Title	Credits
CS 505	Programming, Data Structures, and Algorithms	3
CS 602	Java Programming	3
CS 610	Data Structures and Algorithms	3
CS 611	Introduction to Computability and Complexity	3
CS 631	Data Management System Design	3
CS 632	Advanced Database System Design	3
CS 634	Data Mining	3
CS 675	Machine Learning	3
EM 602	Management Science	3
FIN 624	Corporate Finance II	3
FIN 626	Financial Investment Institutions	3
FIN 650	Investment Analysis and Portfolio Theory	3

MATH 644	Regression Analysis Methods	3
MATH 647	Time Series Analysis II	3
MATH 659	Survival Analysis	3
MATH 662	Probability Distributions	3
MATH 665	Statistical Inference	3
MATH 691	Stochastic Processes with Applications	3
MATH 699	Design and Analysis of Experiments	3
MATH 712	Numerical Methods II	3
MATH 763	Generalized Linear Models	3

Electives are chosen in consultation with the Program Director and consist of advanced courses in mathematics, statistics, probability, computer science, and management (The list above is a partial list of available courses).

Master of Science in Mathematical and Computational Finance - Applied Quantitative Finance Option

(this option does not have electives)

Course	Title	Credits
Semester I		
FIN 641	Derivatives Markets	3
MATH 605	Stochastic Calculus	3
MATH 611	Numerical Methods for Computation	3
PTC 601	Advanced Professional and Technical Communication	3
	Term Credits	12
Semester II		
MATH 604	Mathematical Finance	3
MATH 606	Term Structure Models	3
MATH 608	Partial Differential Equations for Finance	3
MATH 666 or CS 666	Simulation for Finance or Simulation for Finance	3
	Term Credits	12
Semester III		
MATH 607	Credit Risk Models	3
MATH 609	Projects in Mathematical and Computational Finance	3
MGMT 641	Global Project Management	3
	Term Credits	9
	Total Credits	33

Ph.D. in Mathematical Sciences

Degree Requirements

Ph.D. students are admitted to the applied mathematics track or the applied statistics and probability track. In either track, students must fulfill the requirements for the doctor of philosophy as specified in this catalog. Students entering with a bachelor's degree must complete 36 credits of coursework. Those students entering with a master's degree in mathematical sciences or equivalent must complete 12 credits of advanced 700-level coursework. Specific courses of study are planned in consultation with a faculty advisor and are subject to approval. In general, students are encouraged to take courses both in mathematics and in areas of application. To graduate, students must have an approved dissertation and are expected to attain an overall GPA of at least 3.0.

Seminar: In addition to the minimum degree credits required, all doctoral students must enroll each semester in MATH 791 (https://catalog.njit.edu/search/?P=MATH%20791) Graduate Seminar.

Ph.D. in Mathematical Sciences (students with a Master's degree in Mathematical Sciences or equivalent)

Code	Title	Credits
Electives		
700-level courses [1]		12
Dissertation		

MATH 790	Doct Dissertation & Res [2]	
MATH 792B	Pre Doctoral Research [2]	
Seminar		
MATH 791	Graduate Seminar [3]	
Total Credits		12

[1] No more than 6 credits may be MATH 725 Independent Study. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.

[2] Ph.D. students who pass the written and oral qualifying examination must then register for the 1-credit dissertation course (MATH 790 (https://catalog.njit.edu/search/?P=CHE%20790) Doct Dissertation & Res) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 (Pre Doctoral Research) course as per Ph.D. program guidelines or dissertation committee recommendation.

[3] Students must register eight semesters for this seminar. Part-time students may request that this requirement be waived for some semesters.

Ph.D. in Mathematical Sciences (students with a Bachelor’s degree in Mathematical Sciences or equivalent)

Code	Title	Credits
Electives		
600 and 700-level courses [1]		36
Dissertation		
MATH 790	Doct Dissertation & Res [2]	
MATH 792B	Pre Doctoral Research [2]	
Seminar		
MATH 791	Graduate Seminar [3]	
Total Credits		36

[1] Ph.D. students with a recognized Baccalaureate degree are required to take eight 600-level or 700-level 3-credit courses (24 credits) of coursework as well as four additional 700-level 3-credit courses (12 credits), for a total of twelve 3-credit courses (36 credits). No more than 6 credits may be MATH 725 Independent Study. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.

[2] Ph.D. students who pass the written and oral qualifying examination must then register for the 1-credit dissertation course (MATH 790 (https://catalog.njit.edu/search/?P=CHE%20790) Doct Dissertation & Res) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course (Pre Doctoral Research) as per Ph.D. program guidelines or dissertation committee recommendation.
Students must register eight semesters for this seminar. Part-time students may request that this requirement be waived for some semesters.

Courses: A typical schedule of courses for the first two semesters in Applied Mathematics consists of the following:

Course	Title	Credits
First Year		
1st Semester		
MATH 599	Teaching in Mathematics	3
MATH 613	Advanced Applied Mathematics I: Modeling	3
MATH 631	Linear Algebra	3
MATH 645	Analysis I	3
MATH 651	Methods of Applied Mathematics I	3
	Term Credits	15
2nd Semester		
MATH 614	Numerical Methods I	3
MATH 656	Complex Variables I	3
MATH 689	Advanced Applied Mathematics II: Ordinary Differential Equations	3

MATH 745	Analysis II	3
	Term Credits	12
	Total Credits	27

Courses: A typical schedule of courses for the first two semesters in Applied Probability and Statistics consists of the following:

Course	Title	Credits
First Year		
1st Semester		
MATH 599	Teaching in Mathematics	3
MATH 631	Linear Algebra	3
MATH 644	Regression Analysis Methods	3
MATH 645	Analysis I	3
MATH 662	Probability Distributions	3
	Term Credits	15
2nd Semester		
MATH 665	Statistical Inference	3
MATH 699	Design and Analysis of Experiments	3
MATH 745	Analysis II	3
MATH 768	Probability Theory	3
	Term Credits	12
	Total Credits	27

Also, there are advanced courses in:

- partial differential equations
- ordinary differential equations and dynamical systems
- optimization
- numerical methods
- computational electromagnetics
- computational fluid dynamics
- computational neuroscience
- financial mathematics
- integral equations
- materials science
- probability and statistics

Deadlines

- The required coursework for the Ph.D. program and the major part of the qualifying exams must be completed successfully by the end of the second year in the program. The written exams are typically completed by the end of the first summer, and the oral exam by the end of the second year.
- The dissertation proposal must be defended successfully either by the end of the third year in the Ph.D. program.
- The dissertation must be defended successfully by the end of the sixth year in the Ph.D. program.

Selection of Dissertation Advisor

Students select a dissertation topic and advisor in the second year of the program. In cases where more than one advisor is directing the dissertation, the primary advisor must be on the core departmental faculty.

Qualifying Examination

Applied Mathematics track: The qualifying examination for the applied mathematics track consists of a preliminary examination in three parts and an oral examination. The three components of the preliminary examination are: Applied Mathematics, Analysis, and Linear Algebra-Numerical Methods. Students must achieve a grade of A in each component to pass the preliminary examination and proceed to the oral examination. Components may be passed at different times. However, a student may attempt each component at most twice and must pass all three components before taking the oral examination. The qualifying examination must be passed by the end of the second year in the program. Typically, two opportunities to take each component are provided each year: Applied Mathematics (January and May), Analysis and Linear Algebra-Numerical Methods (May and August). The oral examination is usually offered in January and May. The oral exam is intended to test the students research readiness. Exam topics are chosen in consultation with the Ph.D. advisor, and include research papers and coursework relevant to the dissertation topic.

Applied Probability and Statistics track: The qualifying examination for the applied probability and statistics track consists of a preliminary examination in three parts and an oral examination. The three components of the preliminary examination are: Probability Distributions and Regression Analysis Methods, Real Analysis and Statistical Inference, Probability Theory and Design and Analysis of Experiments. Students must achieve a grade of A in each component to pass the preliminary examination and proceed to the oral examination. Components may be passed at different times. However, a student may attempt each component at most twice and must pass all three components before taking the oral examination. The qualifying examination must be passed by the end of the second year in the program. Typically, two opportunities to take each component are provided each year: Probability Distributions and Regression Analysis Methods (January and May), Real Analysis and Statistical Inference and Probability Theory and Design and Analysis of Experiments (May and August). The oral examination is usually offered in January and May. The oral exam is intended to test the students research readiness. Exam topics are chosen in consultation with the Ph.D. advisor, and include research papers and coursework relevant to the dissertation topic.

Dissertation Committee

The dissertation committee is an important resource for the doctoral student in the conduct of research for their dissertation. According to the regulations specified in this catalog, doctoral students are required to have a dissertation advisor selected, a dissertation committee formed, and research proposal approved within one year of passage of the qualifying examination.

Dissertation Proposal

Doctoral students must prepare a research proposal for approval by their dissertation committee. The student must offer an oral defense of this proposal before the dissertation committee and obtain its approval within one year of passing the qualifying examination. The committee determines if the proposal has an appropriate objective, if there is a reasonable plan to reach that objective, and if the student possesses the knowledge and skills needed to carry out the plan. The dissertation proposal can only be approved by unanimous consent of the committee members.

Dissertation Defense

A public oral defense of the dissertation before the dissertation committee is required. All members of the committee must be present for the defense. Success of the defense is determined by a majority vote of the dissertation committee.

Physics

Applied Physics

The NJIT and Rutgers-Newark departments of physics offer a unique opportunity to pursue master's and doctoral degree physics in a joint program combining the resources of two of New Jersey's public research universities.

Interdisciplinary physics research is available in collaboration with faculties of NJIT, Rutgers-Newark and Rutgers-New Brunswick, and RBHSin areas such as device physics, materials research, ultrafast optical and optoelectronic phenomena, imaging technology, surface physics, free electron laser physics, biophysics, discharge physics, solar physics, and applied laser physics. Cooperative research efforts are underway with the National Renewable Energy Laboratory, National Solar Observatory, Lucent Technologies Bell Labs Innovations, U.S. Army Research Laboratory, and other industrial and federal research laboratories.

Master of Science in Applied Physics

The program is for students with an undergraduate degree in physics, applied physics, or engineering, who wish to apply physics to biological problems, optical science, microelectronics, device physics, materials science, solar cells, surface science, laser physics, solar phenomena, and other related areas.

Admission Requirements

A bachelor's degree in physics, applied physics, or related areas from an accredited institution is required. An undergraduate GPA above 3.0 is required. Students must submit GRE (general test) scores. In addition, applicants are required to provide letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Applied Physics

This program is for students in applied physics that are interested in and committed to scholarly research.

Admission Requirements

Applicants are expected to have a master's degree in physics, applied physics, or related engineering disciplines from an accredited institution. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. A GPA of at least 3.5 in undergraduate and previous graduate studies is normally required for admission. The GRE (general test) and advanced (physics) test scores are required. Applicants are required to provide three letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550 (pencil and paper) and 213 (computer-based).

Materials Science and Engineering

This intercollegiate (CSLA and NCE), interdepartmental, and interdisciplinary degree program is intended for individuals with a strong background in science and/or engineering.

Master of Science in Materials Science and Engineering

Admissions Requirement

Applicants are expected to have an undergraduate degree from an accredited institution. A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent is normally required for admission. An undergraduate major in physics, chemistry, materials science, or a related engineering discipline is preferred. GRE quantitative scores of 700 or higher are highly desirable. Students from countries where English is not the native language should demonstrate TOEFL scores higher than 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Materials Science and Engineering

This is an intercollegiate (CSLA and NCE), interdepartmental, and interdisciplinary degree program for superior students who wish to do advanced research in an area of materials science and engineering. Current areas of research include electronic and photonic materials, nano and particulate materials, polymer and biomaterials, and other areas of materials science and engineering.

Admission Requirements

Applicants are expected to have an appropriate master's degree in materials science or related field, physics, chemistry, or engineering from an accredited institution. Students entering with a master's degree must have at least a 3.5 GPA on a 4.0 scale in previous graduate study. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. These students must have at least a 3.5 GPA in undergraduate work.

NJIT Faculty

A

Ahn, Keun Hyuk, Associate Professor

Ahn, Kwangsu, Assistant Research Professor

C

Cao, Wenda, Associate Professor

Chin, Ken K., Professor

Chen, Bin, Assistant Professor

D

Delahoy, Alan E., Research Professor

Deng, Na, Research Professor

Dias, Cristiano Luis, Assistant Professor

F

Farrow, Reginald C., Research Professor

Federici, John F., Distinguished Professor

Fleishman, Gregory David, Distinguished Research Professor

G

Gary, Dale E., Distinguished Professor

Gatley, Ian, Distinguished Professor

Georgiou, George E., University Lecturer

Gerrard, Andrew J., Professor

Gokce, Oktay Huseyin, Senior University Lecturer

Goode, Philip R., Distinguished Research Professor

J

Janow, Richard H., University Lecturer

Jerez, Andres, University Lecturer

Jing, Ju, Research Professor

K

Kosovichev, Alexander G., Professor

L

Lanzerotti, Louis J., Distinguished Research Professor

Levy, Roland A., Distinguished Professor

Liu, Chang, Research Professor

M

Maljian, Libarid A., University Lecturer

N

Nita, Gelu M., Research Professor

O

Opyrchal, Halina, Senior University Lecturer

P

Piatek, Slawomir, Senior University Lecturer

Prodan, Camelia, Associate Professor

R

Ravindra, N. M., Professor

Russo, Onofrio L., Associate Professor

S

Shneidman, Vitaly A., Senior University Lecturer

Sirenko, Andrei, Professor

T

Thomas, Benjamin, Assistant Professor

Thomas, Gordon A., Professor

Towfik, Nissim M., Associate Professor

Tyson, Trevor A., Distinguished Professor

V

Varsik, John R., Research Professor

W

Wang, Haimin, Distinguished Professor

X

Xu, Yan, Research Professor

Y

Yurchyshyn, Vasyl, Research Professor

Z

Zhou, Tao, Associate Professor

Programs

- Applied Physics - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/applied-physics-ms/)
- Materials Science and Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/materials-science-engineering-ms/)

Programs

- Applied Physics - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/applied-physics-phd/)
- Materials Science & Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/materials-science-engineering-phd/)

Physics Courses

PHYS 590. Graduate Coop Work Exp I. 1 credit, 1 contact hour.

PHYS 591. Graduate Coop Work Exp II. 1 credit, 1 contact hour.

PHYS 607. Topics in Astronomy and Cosmology. 3 credits, 3 contact hours.
Prerequisites: college-level physics and mathematics. A survey of recent progress in astronomy, the physical principles involved, and the impact these new discoveries have on our understanding of the universe. Includes results from recent and ongoing planetary probes of our solar system, discovery of planetary systems around other stars, the evolution of stars, exotic objects such as neutron stars and black holes, the formation of galaxies, and current understanding of the birth and final fate of the universe. Observing sessions familiarize students with the sun, moon, and night sky.

PHYS 611. Adv Classical Mechanics. 3 credits, 3 contact hours.

PHYS 621. Classical Electrodynamic. 3 credits, 3 contact hours.

PHYS 641. Statistical Mechanics. 3 credits, 3 contact hours.

PHYS 652. Fund of Optical Imaging. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) This is designed as a principal course of introducing optical engineering to master students in applied optics. The goal is to help students acquire the practical technical knowledge on optical systems and their design. The general approach throughout the course is to emphasize the application of basic optical principles to practice. Topics include general principles of geometric and physical optics, elemental geometric optics under paraxial ray approximation, aberrations, prisms and mirrors, the eye, stops and apertures, optical materials and interference coating, radiometry and photometry, basic optical devices, optical computation, image evaluation and optical system design, particularly computer aided designs.

PHYS 661. Solid-State Physics. 3 credits, 3 contact hours.
Properties of solid state materials are explained based on principles of physics. Electronic, magnetic, thermal, optical, and lattice properties of materials are studied. Various experimental and theoretical approaches are introduced.

PHYS 681. Solar Phys & Instrumentn. 3 credits, 3 contact hours.

PHYS 682. Introduction To Mems. 3 credits, 3 contact hours.

PHYS 687. Physics of Materials. 3 credits, 3 contact hours.
Prerequisite: PHYS 441 or equivalent (see undergraduate catalog for description). Fundamentals of quantum mechanics; energy bands in crystals; electrical conduction in metals and alloys, semiconductors; optical properties of materials; quantum mechanical treatment of optical properties; magnetic properties of materials; thermal properties, heat capacity, and thermal expansion in solids.

PHYS 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
More emphasis on analytical methods and statistics. Course will be required for Ph.D. students in Materials Science.

PHYS 690. Directed Study Appl Phys. 3 credits, 3 contact hours.

PHYS 698. ST:. 3 credits, 3 contact hours.

PHYS 700. Master'S Project. 3 credits, 3 contact hours.
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics who do not take Phys 701 Master's Thesis. An extensive paper involving experimental or theoretical investigation of a topic in microelectronics or other applied physics area is required. Cooperative projects with industry or government agencies may be acceptable. The project is carried out under the supervision of a designated physics graduate faculty member.

PHYS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. A written report must be submitted to the project advisor. The student cannot register in PHYS 700B more than once and the incomplete (I) grade is not allowed.

PHYS 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics. Experimental or theoretical investigation of a topic in microelectronics or other applied physics area. Cooperative projects with industry or government agencies may be acceptable. The thesis is written under the supervision of a designated physics graduate faculty member. The completed written thesis should be of sufficient merit to warrant publication in a scientific or technical journal. The student must register for a minimum of 3 credits per semester. Degree credit is limited to 6 credits indicated for the thesis.

PHYS 701B. Master'S Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in PHYS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHYS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (PHYS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHYS 721. Classical Electrodynamics II. 3 credits, 3 contact hours.
Prerequisite: PHYS 621 or equivalent; basic knowledge of tensor analysis. Simple radiating systems, scattering and diffraction; special theory of relativity; dynamics of relativistic particles and electromagnetic fields; collisions between charged particles, energy loss, and scattering; radiation from accelerated charge, synchrotron radiation, and bremsstrahlung.

PHYS 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

PHYS 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for PHYS 726 if they have taken PHYS 725 in a prior semester.

PHYS 728. Radio Astronomy. 3 credits, 3 contact hours.
Prerequisites: PHYS 621and PHYS 641 or the equivalent, or approval of the instructor. An introduction to radio emission processes, radiative transfer, radio diagnostics, and radio instrumentation. Topics include radio flux measurements with single antenna, radio imaging with interferometer arrays (Fourier Transform imaging), and image reconstruction techniques (CLEAN, MEM). Application is to astronomical objects with special emphasis on the Sun.

PHYS 731. Quantum Mechanics II. 3 credits, 3 contact hours.
Prerequisite: PHYS 631 or equivalent. Review of quantum mechanics and theory of special relativity; second quantization; relativistic one-particle problem; Klein-Gordon equation and Dirac equation; canonical field theory; relativistic scattering theory; introduction to quantum electrodynamics and quantum field theory; Feynman diagrams and applications.

PHYS 741. Basic Plasma Phys w Space, Lab. 3 credits, 3 contact hours.
Prerequisites: PHYS 611, PHYS 621, other equivalent, or approval of the instructor. The course will introduce students to basic concepts of plasma physics and its applications to laboratory experiments and space research. The course will cover the following topics: particle motions in magnetic field, adiabatic invariants, magnetic traps, radiation belts, electromagnetic waves in plasma, electrostatic oscillations, waves in magnetized plasma, collisional processes in plasma, kinetic effects on plasma waves, Landau damping, wave instabilities, plasma as fluid, magnetohydrodynamics, magnetic configurations of laboratory and space plasma, MHD instabilities, reconnection, helicity, dynamo theories, the origin of cosmic magnetic fields, stochastic processes, Fermi process, particle acceleration, and cosmic rays.

PHYS 747. Intro to Helioseismology. 3 credits, 3 contact hours.
Prerequisites: Phys 611, Phys 621 or other equivalent The course will introduce the physical principles and methods to study wave oscillations, and the interior structure of the Sun. The course covers processes of acoustic and gravity wave excitation and propagation, interaction with turbulence and magnetic fields, oscillation spectrum, sunquakes, inferences of the structure and composition, the differential rotation, large-scale flows and meridional circulation. It includes the theory of normal modes, inversion techniques, wave dispersion analysis, acoustic tomography and holography, applications to the solar dynamo and magnetic activity.

PHYS 751. Applied Optics. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) The course will introduce students to basic concepts of applied optics, light propagation and light and matter interactions. The course will cover the following topics: light propagation through mirrors and lenses, matrix optics, basic concepts of wave optics, reflection, refraction and transmission, equations governing wave propagation, Gaussian beams, Maxwell’s equations, absorption, dispersion, light polarization states, temporal and spatial coherences.

PHYS 753. Light Sources & Photodetectors. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) and PHYS 631 (Quantum Mechanics I) This is a survey course on theory and practical aspects of light sources and photodetectors. The specific light sources covered will be: black body, discharge tubes, X-ray, light.

PHYS 774. Fundamentals of Spectroscopy. 3 credits, 3 contact hours.
The major objectives of this course are to integrate theory and practice and to bring together different branches of Academic Studies and Industrial Research through the presentation of critical aspects of modern Spectroscopy. The course will provide a valuable theoretical introduction and an overview of modern topics in spectroscopy, which are of current interest and importance in Semiconductor Industry and Biomedicine. A wide range of techniques is considered, including optical Near field spectroscopy, X-ray, Raman, Neutron scattering, and FT-IR spectroscopy.

PHYS 780. Curr Topics Applied Phys. 3 credits, 3 contact hours.

PHYS 787. New Concepts of Semiconductor. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 and ECE 657. This is an advanced course on semiconductor physics targeted at describing polycrystalline materials, e.g. cadmium telluride or copper indium diselenide, that are currently used in thin-gilm photovoltiac panels. An overview of classical semiconductor and solar cell theory is followed by topics such as non-shallow dopants, multi-level defects, defect transition energy level, and metastability. These concepts are applied to examine minority carrier lifetime and carrier collection in devices, and to extend the theories of admittance and deep level transient spectroscopy.

PHYS 789. Physics of Advanced Semiconductor Device Processing. 3 credits, 3 contact hours.
Prerequisites: NJIT: EE 657, R755 687; or equivalent. Intended for doctoral students in applied physics, electrical engineering, and materials science. (Rutgers = R755 789)Silicon and GaAS technologies: crystal growth methods, epitaxy, oxidation, lithography, dry and wet etching techniques, polysilicon, diffusion, ion implantation, metallization (including silicidation), process integration, analytical characterization techniques, assembly and packaging, and yield and reliability.

PHYS 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Prerequisites: passing grade on departmental qualifying examination and approval of doctoral candidacy. Corequisite: PHYS 791. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester. Registration for additional credits, up to 12 per semester, is permitted with the approval of the department graduate advisor. Experimental or theoretical investigation of a topic in applied physics, including microelectronics, materials science, and laser physics. Cooperative projects with industry or government agencies may be acceptable. Research and writing are carried out under the supervision of a designated graduate faculty member. The completed written dissertation should be a substantial contribution to the knowledge of the topic under research, and should be of sufficient merit to warrant publication in a leading scientific or technical journal.

PHYS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: PHYS 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. For PhD students who have successfully defended their dissertation proposal. The student must register in PHYS 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

PHYS 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: PHYS 791. Since the PHYS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

PHYS 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: PHYS 791. Since the PHYS 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in applied physics. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

PHYS 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

PHYS 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

PHYS 790F. Doct Dissertation & Res. 15 credits, 3 contact hours.

PHYS 790G. Doct Dissertation & Res. 18 credits, 3 contact hours.

PHYS 791. Doctoral Seminar. 0 credits, 0 contact hours.

PHYS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: PHYS 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in applied physics. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

Rutgers-Newark Courses

R750 501. Quantum Mechanics. 3 credits, 3 contact hours.

R750 509. Physics Appli Cmptrs. 3 credits, 3 contact hours.

R750 537. Recent Intl. Relations. 3 credits, 0 contact hours.

R750 543. Galaxies And Milky Ways. 3 credits, 3 contact hours.

R750 601. Solid State Physics I. 3 credits, 0 contact hours.

R750 602. Solid State Physics II. 3 credits, 3 contact hours.

R750 617. Genl Theo Relativity. 3 credits, 0 contact hours.

R750 620. Many Body Physics. 3 credits, 3 contact hours.

R750 621. Adv Many Body. 3 credits, 3 contact hours.

R750 681. Adv Top Sol State. 3 credits, 3 contact hours.

R750 771. Quantum Electronics. 3 credits, 3 contact hours.

R755 631. Quantum Mechanics. 3 credits, 3 contact hours.

R755 701. Dissertation Research. 3 credits, 0 contact hours.

R755 702. Diss Research. 3 credits, 0 contact hours.

R755 771. Quantum Electronics. 3 credits, 0 contact hours.

R755 772. Plasma Physics. 3 credits, 0 contact hours.

R755 774. Intro To Spectro. 3 credits, 0 contact hours.

R755 780. Adv Quantum Mech. 3 credits, 3 contact hours.

R755 866. Grad Assistant. 6 credits, 3 contact hours.

M.S. in Applied Physics

A minimum of 30 degree credits (600 or 700 level), including a 6-credit thesis or a 3-credit project is required. Of the 30 credits, 18 must be physics courses (including 3 credits of mathematical physics or applied mathematics). The remaining 12 to 15 credits are elective courses.

Seminar: In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in PHYS 791 Doctoral Seminar.

M.S. in Applied Physics (Master's project)

Code	Title	Credits
Required Courses		
PHYS 611	Adv Classical Mechanics	3
PHYS 621	Classical Electrodynamic	3
R755 631	Quantum Mechanics	3

PHYS 641	Statistical Mechanics	3
Project		
PHYS 700B	Master's Project	3
Electives		
Five electives [1]		15
Total Credits		30

[1] Selected in consultation with a graduate advisor.

M.S. in Applied Physics (Master's thesis)

Code	Title	Credits
Required Courses		
PHYS 611	Adv Classical Mechanics	3
PHYS 621	Classical Electrodynamic	3
R755 631	Quantum Mechanics	3
PHYS 641	Statistical Mechanics	3
Thesis		
PHYS 701C	Master's Thesis	6
Electives		
Four electives [1]		12
Total Credits		30

[1] Selected in consultation with a graduate advisor.

M.S. in Materials Science and Engineering

The program is offered in two options, the Materials Science option and the Materials Engineering option. These options are administered by the CSLA (College of Science and Liberal Arts) and NCE (Newark College of Engineering) colleges, respectively. A joint committee involving CSLA and NCE faculty will be in charge of overseeing this program.

Students learn about the synthesis, properties, modeling, and applications of various materials in this program. There are two options in this program - Materials Science Option and Materials Engineering Option.

Materials Science Option

Administered by Department of Physics, CSLA

Degree Requirements

Students who lack appropriate undergraduate preparation for the program may be admitted and required to make up deficiencies by taking a program of bridge courses which is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Candidates must complete a minimum of 30 credits, including 12 credits of required materials science courses and 18 credits in a track, which are selected in consultation with the program director or graduate advisor. The 30 credits could include 3 credits of MTSE 700 Master’s Project or 6 credits of MTSE 701 Master’s Thesis, but not both.

Seminar

All students must enroll each semester in MTSE 791 (Graduate Seminar, 0 credit), unless the requirement is waived by the Director for Materials Science Option of Materials Science and Engineering program.

Track

The range of possible tracks and courses is broad and is not limited to the tracks and courses listed here. Students should consult the graduate advisor in designing the track and the course requirements of the track.

Cross-listed courses

Any cross-listed courses will not be offered simultaneously, but only one of the two will be offered at a time.

M.S. in Materials Science and Engineering – Materials Science Option

Code	Title	Credits
Required Courses (2 common and 2 selective courses)		
MTSE 601	Fundamentals of Engineering Materials	3
or MTEN 610	Found of Materials Sci & Engr	
MTSE 602	Thermodynamics of Materials	3
or MTEN 612	Thermodynamics of Materials	
Select two of the following four courses:		6
MTSE 603	Intro to Phys Prin of Material	
MTSE 688	Mathematical and Statistical Methods in Materials Science	
MTSE 765	Science and Technology of Thin Films	
CHEM 748	Nanomaterials	
or MTEN 712	Nanomaterials	
Area of Specialization [1]		
Select six courses from one of the following areas:		18
Electronic and Photonic Materials		
MTSE 603	Intro to Phys Prin of Material	
MTSE 688	Mathematical and Statistical Methods in Materials Science	
MTSE 765	Science and Technology of Thin Films	
CHEM 748	Nanomaterials	
or MTEN 712	Nanomaterials	
MTSE 610	Mechanical Properties of Materials	
MTSE 655	Diffusion and Solid State Kinetics	
or MTEN 611	Diffusion & Solid State Kineti	
MTSE 681	Composite Materials	
MTSE 719	Physical Principles of Characterization of Solids	
MTSE 724	Transport of Electrons and Phonons in Solids	
MTSE 725	Crystallography and Diffraction	
PHYS 661	Solid-State Physics	
PHYS 682	Introduction To Mems	
PHYS 687	Physics of Materials	
PHYS 789	Physics of Advanced Semiconductor Device Processing	
PHYS 611	Adv Classical Mechanics	
PHYS 621	Classical Electrodynamic	
PHYS 641	Statistical Mechanics	
R755 631	Quantum Mechanics	
PHYS 731	Quantum Mechanics II	
CHEM 610	Advanced Inorganic Chemistry	
CHEM 658	Advanced Physical Chemistry	
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	
CHEM 764	Advanced Analytical Chemistry	
CHE 702	Selected Topics in Chemical Engineering II	
ECE 625	Fiber and Integrated Optics	
ECE 626	Optoelectronics	
ECE 657	Semiconductor Devices	
ECE 658	VLSI Design I	
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices	
ECE 739	Laser Systems	
Particulate and Nano Materials		
MTSE 603	Intro to Phys Prin of Material	
MTSE 688	Mathematical and Statistical Methods in Materials Science	
MTSE 765	Science and Technology of Thin Films	

CHEM 748	Nanomaterials
or MTEN 712	Nanomaterials
MTSE 610	Mechanical Properties of Materials
MTSE 655	Diffusion and Solid State Kinetics
or MTEN 611	Diffusion & Solid State Kineti
MTSE 681	Composite Materials
MTSE 719	Physical Principles of Characterization of Solids
MTSE 655	Diffusion and Solid State Kinetics
or MTEN 611	Diffusion & Solid State Kineti
MTSE 725	Crystallography and Diffraction
CHEM 605	Advanced Organic Chemistry I: Structure
CHEM 610	Advanced Inorganic Chemistry
CHEM 658	Advanced Physical Chemistry
CHEM 673	Biochemistry
CHEM 737	Applications of Computational Chemistry and Molecular Modeling
CHEM 764	Advanced Analytical Chemistry
BME 669	Engineering Physiology
BME 672	Biomaterials
CHE 681	Polymerization-Principles and Practice
CHE 682	Polymer Structures and Properties
CHE 627	Introduction to Biomedical Engineering
PHYS 661	Solid-State Physics
PHYS 682	Introduction To Mems
PHYS 687	Physics of Materials
PHYS 611	Adv Classical Mechanics
PHYS 621	Classical Electrodynamic
PHYS 641	Statistical Mechanics
R755 631	Quantum Mechanics
PHYS 731	Quantum Mechanics II
ME 676	Applied Plasticity
ME 678	Engineering Design of Plastic Products
Mathematical and Computational Materials Science Track	
MTSE 603	Intro to Phys Prin of Material
MTSE 688	Mathematical and Statistical Methods in Materials Science
MATH 611	Numerical Methods for Computation
MATH 613	Advanced Applied Mathematics I: Modeling
MATH 666	Simulation for Finance
MATH 671	Asymptotic Methods I
MATH 675	Partial Differential Equations
MATH 677	Calculus of Variations
MATH 689	Advanced Applied Mathematics II: Ordinary Differential Equations
MATH 690	Advanced Applied Mathematics III: Partial Differential Equations
MATH 712	Numerical Methods II
MATH 713	Advanced Scientific Computing: Multi-Dimensional Finite-Difference Schemes and Spectral Methods
MATH 722	Wave Propagation
MATH 767	Fast Numerical Algorithms
MATH 661	Applied Statistics
PHYS 661	Solid-State Physics
PHYS 611	Adv Classical Mechanics
PHYS 621	Classical Electrodynamic
PHYS 641	Statistical Mechanics
R755 631	Quantum Mechanics

PHYS 731	Quantum Mechanics II	
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	
MTSE 765	Science and Technology of Thin Films	
CHEM 748	Nanomaterials	
or MTEN 712	Nanomaterials	
Project		
MTSE 700B	Master's Project	
Thesis		
MTSE 701B	Master's Thesis	
Total Credits		30

Ph.D. in Applied Physics

Degree Requirements

Ph.D. in Applied Physics (with bachelor's degree)

Code	Title	Credits
Course Work [1]		**36**
PHYS 611	Adv Classical Mechanics	3
PHYS 621	Classical Electrodynamic	3
R755 631	Quantum Mechanics	3
PHYS 641	Statistical Mechanics	3
PHYS 721	Classical Electrodynamics II	3
PHYS 731	Quantum Mechanics II	3
Two physics courses		6
Two additional 700 -level physics courses		6
Electives (Four 3-credit courses)		12
PHYS 791	Doctoral Seminar [2]	0

1 No less than 12 credits must be at the 700 level.

2 All doctoral students must enroll in each semester, including each semester they are enrolled in .

3 PHYS 792B Pre-doctoral Research[3]
Students who pass the Qualifying Examination (QE) must then register in PHYS 792B every semester until they defend successfully the dissertation proposal 3

4 PHYS 790A Doctoral Dissertation and Research[4]
Students who defend the dissertation proposal successfully must then register in PHYS 790A every semester until they complete all degree requirements 1

Ph.D. in Applied Physics (with master's degree)

Code	Title	Credits
Course Work [1]		**24**
PHYS 611	Adv Classical Mechanics [5]	3
PHYS 621	Classical Electrodynamic [5]	3
PHYS 641	Statistical Mechanics [5]	3
R755 631	Quantum Mechanics [5]	3
PHYS 721	Classical Electrodynamics II [5]	3
PHYS 731	Quantum Mechanics II [5]	3
Two additional 700 -level physics courses		6
PHYS 791	Doctoral Seminar [2]	0

1 No less than 12 credits must be at the 700 level.

2 All doctoral students must enroll in the seminar course every semester they are enrolled in PHYS 792B or PHYS 790A.

3	PHYS 792B Pre-doctoral Research[3] Students who pass the Qualifying Examination (QE) must then register in PHYS 792B every semester until they defend successfully the dissertation proposal	3
4	PHYS 790A Doctoral Dissertation and Research[4] Students who defend the dissertation proposal successfully must then register in PHYS 790A every semester until they complete all degree requirements	1

Qualifying Examination and Research Examination

The student must pass a written qualifying examination and oral research examination. The written qualifying examination is administered yearly to test general academic preparation and competence for research in applied physics. Within one year after passing the written qualifying examination, the student is required to pass the oral qualifying examination to achieve Ph.D. candidacy, in which the prospective Ph.D. candidate presents a preliminary research proposal for approval by the dissertation committee. The student will be allowed two attempts to pass the written or oral qualifying examination.

Dissertation and Defense

An oral presentation and defense of the doctoral dissertation is required. A five-member committee, chaired by the dissertation advisor, must approve the content and presentation of the dissertation research.

Ph.D. in Materials Science and Engineering

The program is offered in two options, the Materials Science option **(**http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/materials-science-engineering-phd/**) and the** Materials Engineering option **(**http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-phd/**). These options are administered by the CSLA (College of Science and Liberal Arts) and NCE (Newark College of Engineering) colleges, respectively. A joint committee involving CSLA and NCE faculty will be in charge of overseeing this program.**

Materials Science Option

Administered by Department of Physics, CSLA

Degree Requirements

Students with an appropriate master's degree in materials science or related field, physics, chemistry or engineering, are required to complete a course work of 12 credits in 700 level courses beyond the master's degree. Students must also complete sufficient credits of dissertation research (MTSE 790) and meet the milestone deadlines, as specified by the Office of Graduate Studies. Specific course selection, the track and dissertation topics are approved by the program advisor on an individual basis.

Students entering with bachelor's degrees are required to complete a course work of 36 credits. Students must also complete sufficient credits of dissertation research (MTSE 790) and meet the milestone deadlines, as specified by the Office of Graduate Studies. For the course work, the required courses for the M.S. in Materials Science are mandatory; no less than 12 credits must be at the 700 level and none at the 500 level. Specific course selection, the track, and dissertation topics are approved by the program advisor on an individual basis.

Seminar

All students must enroll each semester in MTSE 791 (http://catalog.njit.edu/archive/2019-2020/search/?P=MTSE%20791) Graduate Seminar (0 credit), unless the requirement is waived by the Director for Materials Science Option of Materials Science and Engineering program.

Tracks

The range of possible tracks and courses is broad and is not limited to the tracks and courses listed here. Students should consult the graduate advisor in designing the track and course requirements of the track.

Cross-listed courses

Any cross-listed courses will not be offered simultaneously, but only one of the two will be offered at a time.

Ph.D. in Materials Science and Engineering – Materials Science option (entering with master's degree)

Code	Title	Credits
700-level courses in a chosen track		12
MTSE 791	Graduate Seminar	
Total Credits		12

Ph.D. in Materials Science and Engineering – Materials Science option (entering with bachelor's degree)

Code	Title	Credits
Required Courses (2 common and 2 selective courses)		
MTSE 601	Fundamentals of Engineering Materials	3
or MTEN 610	Found of Materials Sci & Engr	
MTSE 602	Thermodynamics of Materials	3
or MTEN 612	Thermodynamics of Materials	
Select two of the following four courses		9
MTSE 603	Intro to Phys Prin of Material	
MTSE 688	Mathematical and Statistical Methods in Materials Science	
MTSE 765	Science and Technology of Thin Films	
CHEM 748	Nanomaterials	
or MTEN 712	Nanomaterials	
Remaining courses		
600- or 700-level courses in a chosen track		
700-level courses in a chosen track		
MTSE 791	Graduate Seminar	0
Total Credits of Course Work		36

* No less than 12 credits must be at the 700 level, including credits from the required courses.

Tracks

Electronic and Photonic Materials Tracks

Code	Title	Credits
MTSE 603	Intro to Phys Prin of Material	3
MTSE 688	Mathematical and Statistical Methods in Materials Science	3
MTSE 765	Science and Technology of Thin Films	3
CHEM 748	Nanomaterials	3
or MTEN 712	Nanomaterials	
MTSE 610	Mechanical Properties of Materials	3
MTSE 655	Diffusion and Solid State Kinetics	3
or MTEN 611	Diffusion & Solid State Kineti	
MTSE 681	Composite Materials	3
MTSE 719	Physical Principles of Characterization of Solids	3
MTSE 719	Physical Principles of Characterization of Solids	3
MTSE 724	Transport of Electrons and Phonons in Solids	3
PHYS 661	Solid-State Physics	3
PHYS 682	Introduction To Mems	3
PHYS 687	Physics of Materials	3
PHYS 789	Physics of Advanced Semiconductor Device Processing	3
PHYS 611	Adv Classical Mechanics	3
PHYS 621	Classical Electrodynamic	3
PHYS 641	Statistical Mechanics	3
R755 631	Quantum Mechanics	3
PHYS 731	Quantum Mechanics II	3
CHEM 610	Advanced Inorganic Chemistry	3
CHEM 658	Advanced Physical Chemistry	3
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	3
CHEM 764	Advanced Analytical Chemistry	3
CHE 702	Selected Topics in Chemical Engineering II	3
ECE 625	Fiber and Integrated Optics	3
ECE 626	Optoelectronics	3
ECE 657	Semiconductor Devices	3

ECE 658	VLSI Design I	3
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices	3
ECE 739	Laser Systems	3

Particulate and Nano Materials Track

Code	Title	Credits
MTSE 603	Intro to Phys Prin of Material	3
MTSE 688	Mathematical and Statistical Methods in Materials Science	3
MTSE 765	Science and Technology of Thin Films	3
CHEM 748	Nanomaterials	3
or MTEN 712	Nanomaterials	
MTSE 610	Mechanical Properties of Materials	3
MTSE 655	Diffusion and Solid State Kinetics	3
or MTEN 611	Diffusion & Solid State Kineti	
MTSE 681	Composite Materials	3
MTSE 719	Physical Principles of Characterization of Solids	3
CHEM 605	Advanced Organic Chemistry I: Structure	3
CHEM 610	Advanced Inorganic Chemistry	3
CHEM 658	Advanced Physical Chemistry	3
CHEM 673	Biochemistry	3
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	3
CHEM 764	Advanced Analytical Chemistry	3
BME 669	Engineering Physiology	3
BME 672	Biomaterials	3
PHYS 661	Solid-State Physics	3
PHYS 682	Introduction To Mems	3
PHYS 687	Physics of Materials	3
PHYS 611	Adv Classical Mechanics	3
PHYS 621	Classical Electrodynamic	3
PHYS 641	Statistical Mechanics	3
R755 631	Quantum Mechanics	3
PHYS 731	Quantum Mechanics II	3
ME 676	Applied Plasticity	3
ME 678	Engineering Design of Plastic Products	3

Mathematical and Computational Materials Science Track

Code	Title	Credits
MTSE 603	Intro to Phys Prin of Material	3
MTSE 688	Mathematical and Statistical Methods in Materials Science	3
MATH 611	Numerical Methods for Computation	3
MATH 613	Advanced Applied Mathematics I: Modeling	3
MATH 666	Simulation for Finance	3
MATH 671	Asymptotic Methods I	3
MATH 675	Partial Differential Equations	3
MATH 677	Calculus of Variations	3
MATH 689	Advanced Applied Mathematics II: Ordinary Differential Equations	3
MATH 690	Advanced Applied Mathematics III: Partial Differential Equations	3
MATH 712	Numerical Methods II	3
MATH 713	Advanced Scientific Computing: Multi-Dimensional Finite-Difference Schemes and Spectral Methods	3
MATH 722	Wave Propagation	3
MATH 767	Fast Numerical Algorithms	3
PHYS 661	Solid-State Physics	3

PHYS 611	Adv Classical Mechanics	3
PHYS 621	Classical Electrodynamic	3
PHYS 641	Statistical Mechanics	3
R755 631	Quantum Mechanics	3
PHYS 731	Quantum Mechanics II	3
CHEM 737	Applications of Computational Chemistry and Molecular Modeling	3
MTSE 765	Science and Technology of Thin Films	3
CHEM 748	Nanomaterials	3
or MTEN 712	Nanomaterials	

Qualifying Examination

The student must pass a written and an oral qualifying examination. The written qualifying exam given every summer is administered to test general academic preparation and competence in the research of Materials Science. Within one year after passing the written qualifying exam, the student is required to pass the oral qualifying exam to achieve Ph.D. candidacy, in which the potential Ph.D. candidate presents a preliminary research proposal for approval by the dissertation committee. The student will be allowed two attempts to pass the written or oral qualifying exam.

Students take written qualifying exams on the following common required courses.

Code	Title	Credits
MTSE 601	Fundamentals of Engineering Materials	3
or MTEN 610	Found of Materials Sci & Engr	
MTSE 602	Thermodynamics of Materials	3
or MTEN 612	Thermodynamics of Materials	

Formation of Dissertation Committee

Within one year of passing the written qualifying examination, doctoral students must form a five-member dissertation committee that meets the approval of the graduate program director for Materials Science Option of Materials Science and Engineering. The committee must include the dissertation advisor, three additional faculty members from the program, and at least one member from outside the program or NJIT.

Dissertation and Defense

An oral presentation and public defense of the doctoral dissertation is required.

Newark College of Engineering

One of the oldest and largest professional engineering schools in the United States, Newark College of Engineering offers 10 undergraduate degree programs, 21 master's and 9 doctoral degree programs. Undergraduate enrollment is more than 3,500, and more than 1,400 are enrolled in graduate study. The 150-member faculty includes engineers and scholars who are widely recognized in their fields.

Programs

- Biomedical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/ms/)
- Biopharmaceutical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/biopharmaceutical-ms/)
- Chemical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/chemical-ms/)
- Civil Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/)
- Civil Engineering - M.S. online (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms-online/)
- Computer Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/computer-ms/)
- Critical Infrastructure Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/critical-infrastructure-systems-ms/)
- Electrical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/electrical-ms/)
- Engineering Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/)
- Engineering Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/interdisciplinary-engineering-science/ms/)
- Environmental Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-ms/)

- Healthcare Systems Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/healthcare-systems-management-ms/)
- Industrial Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/industrial-ms/)
- Internet Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/internet-ms/)
- Manufacturing Systems Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/manufacturing-systems-ms/)
- Materials Science and Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-ms/)
- Mechanical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/mechanical-ms/)
- Occupational Safety and Health Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/occupational-safety-health-ms/)
- Pharmaceutical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-ms/)
- Pharmaceutical Systems Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/pharmaceutical-systems-management-ms/)
- Power and Energy Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/power-energy-systems-ms/)
- Telecommunications - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/telecommunications-ms/)
- Transportation - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-ms/)

Double Majors (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/special-programs/)

- Architecture - M.Arch. and Civil Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-civil-engineering-ms/)

Programs

- Biomedical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/phd/)
- Chemical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/chemical-phd/)
- Civil Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-phd/)
- Computer Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/computer-phd/)
- Electrical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/electrical-phd/)
- Environmental Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-phd/)
- Industrial Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/industrial-phd/)
- Materials Science & Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-phd/)
- Mechanical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/mechanical-phd/)
- Transportation - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-phd/)

Programs

- Biomedical Device Development (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/cert/)
- Construction Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/construction-management-cert/)
- Environmental Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-engineering-studies-cert/)
- Environmental Science and Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-science-engineering-cert/)
- Hydrology and Water Resources Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/hydrology-and-water-resources-engineering-cert/)
- Intelligent Transportation Systems (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/intelligent-transportation-systems-cert/)

- Pharmaceutical Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-management-cert/)
- Pharmaceutical Manufacturing (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-manufacturing-cert/)
- Pharmaceutical Technology (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-technology-cert/)
- Power Systems Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/power-systems-engineering-cert/)
- Polymers and Plastics (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/polymers-and-plastics-cert/)
- Project Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/project-management-cert/)
- Supply Chain Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/supply-chain-engineering-cert/)
- Transportation Studies (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-studies-cert/)

BME 590. Graduate Co-Op Work Exper I. 1 credit, 1 contact hour.

BME 591. Graduate Co-Op Work Exper II. 1 credit, 1 contact hour.

BME 592. Graduate Co-Op Work Exper III. 1 credit, 1 contact hour.

BME 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

BME 601. Seminar. 1 credit, 1 contact hour.
Required every semester of all master's students in biomedical engineering who receive departmental or research-based support and all doctoral students. To receive a satisfactory grade, students must attend at least five seminars per semester, as approved by the seminar supervisor.

BME 611. Engineering Aspect of Molecular and Cellular Bio I. 1 credit, 1 contact hour.
Molecular and cellular biology is a foundation of the understanding of the biological sciences and is vital to the study of advanced biomedical engineering. This course is to be taken simultaneously with UMDNJ N551 to enrich the crossover between engieering and life sciences. Course topics parallel those covered in N551 and both add engineering relevance, and provide engineering students with a stronger understanding of molecular and cellular biology. For students in joint BME PhD program.

BME 612. Engineering Aspects of Molecular and Cellular Bio 2. 1 credit, 1 contact hour.
Molecular and cellular biology is a foundation of the understanding of the biological sciences and is vital to the study of advanced biomedical engineering. This course is to be taken simultaneously with UMDNJ N552 to enrich the crossover between engineering and life sciences. Course topics parallel those covered in N552 and both add engineering relevance, and provide engineering students with a stronger understanding of molecular and cellular biology. For students in joint BME PhD program.

BME 650. Clinical Physiology & Neurophy. 3 credits, 3 contact hours.
Prerequisites: BME 111, BME 303, BME 382 or permission of the instructor. Topics to be covered include gastrointestinal tract, pulmonary respiratory system, renal and liver functions, blood and hemodynamic, cardiovascular and cerebrovascular function, and understanding of neurophysiology in human neurological diseases.

BME 651. Principles of Tissue Engineering. 3 credits, 3 contact hours.
Tissue Engineering is a therapeutic approach to treating damaged or diseased tissues in the biotechnology industry. In essence, new and functional living tissue can be fabricated using living cells combined with a scaffolding material to guide tissue development. Such scaffolds can be synthetic, natural, or a combination of both. This course will cover the advances in the fields of cell biology, molecular biology, and materials science towards developing novel "tissue engineered" materials.

BME 652. Cellular and Molecular Tissue Engineering. 3 credits, 3 contact hours.
This course explores molecular, cellular and tissue level interactions that are an important component of all tissue engineering strategies. Topics include how a cell moves, reacts and maintains viability and function based on its surroundings. We will discuss how to engineer our materials, tissue grafts and implants to integrate with the body. We will also liearn about bodily reactions and the biocompatibility of tissue engineered devices such as immunoreactivity and blood coagulation.

BME 653. Micro/Nanotechnologies for Interfacing Live Cells. 3 credits, 3 contact hours.
In this course, we will study technologies and tools available for interfacing live cells from a sub-cellular, single-cell, and multi-cellular (tissue models) approach. We will introduce key concepts of the biology of cells and tissues and will explore the technologies (micro-/nanotechnologies) and tools (sensors and actuators) available for the investigation of cell and tissue biology. Same as ECE 653.

BME 654. Cardiovascular Mechanic. 3 credits, 3 contact hours.
Fundamental biomechanical mechanisms at work in the cardiovascular system. Topics include the fundamental molecular structure of heart muscle, the biomechanical principles that transform the contraction of heart muscle into stress-strain functions of muscle fibers, pressure-volume flow relations in the vasculature when it is considered as a hemodynamic (blood hydraulic) system, growth and disease of the cardiovascular system, resistance, compliance, inertance, and catheter-tip transducers.

BME 655. Advanced Characterization of Biomaterials. 3 credits, 3 contact hours.
Prerequisites: MTSE 301 or undergraduate equivalent, BIOL 201 or undergraduate equivalent, one semester of undergraduate organic chemistry. With a focus on contemporary biomaterials in the published literature and clinical practice, biomaterial chemical and mechanical testing will complement synthesis theory. Communication and articulation of ideas will be honed in the form of literature debates, write-ups, demonstration/performance of analytical techniques, and concluding with translation of biomaterials that will include entrepreneurship and regulatory aspects.

BME 656. Research Skills in Stem Cell. 3 credits, 3 contact hours.
Stem cells have emerged as new therapeutic potential and offer great opportunities for regenerative medicine, biotechnology and the pharmaceutical industry. This course is intended for graduate students interested in stem cell bioengineering and tissue engineering. The course will cover stem cell biology and biomedical engineering applications for cell-based regeneration therapies. It will discuss techniques for engineering of stem cells and the current literature in this rapidly evolving field.

BME 661. Neural Engineering. 3 credits, 3 contact hours.
Neural Engineering focuses on understanding how the brain functions using engineering principles. The course discusses different instrumentation and signal processing algorithms to study how the brain functions, how to detect different pathologies and new applications for research. Topics include; basic overview of neurology, vector populations, neural networks, vision research, functional MRI, functional electrical stimulation, neural prosthetics, and other advanced research topics studying neurology.

BME 667. Bio-Control Systems. 3 credits, 3 contact hours.
The course provides an introduction to dynamic and control in biological systems, with particular emphasis on engineering aspects of biological oscillators/waves which govern the basic operations of all living organisms and especially higher order life forms. A combination of theoretical and simulation tools will be applied to analyze the qualitative and quantitative properties of selected biological systems. Feedback and control mechanisms in selected biological systems will be introduced. Same as ECE 667.

BME 668. Medical Imaging Systems. 3 credits, 3 contact hours.
This course provides a detailed introduction to medical imaging physics, instrumentation, data acquisition and image processing systems for reconstruction of multi-dimensional anatomical and functional medical images. Three-Dimensional medical imaging modalities including X-ray, Computer Tomography, Magnetic Resonance Imaging, Single Photon Emission Computer Tomography, Positron Emission Tomography, Ultrasound and optical imaging modalities are included. Same as ECE 668.

BME 669. Engineering Physiology. 3 credits, 3 contact hours.
To enable students to apply basic tools in engineering analysis, mathematics, computer science, general physics and chemistry courses so that they can develop models that quantitatively predict the functioning of physiological systems in the human body. To enable students to apply engineering systems analysis to systematic physiology and employ the ideas of feedback control, signal procession, mathematical modeling and numerical simulation. Same as ECE 669.

BME 670. Introduction to Biomechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment. Same as ME 670.

BME 671. Biomechanics of Human Structure and Motion. 3 credits, 0 contact hours.
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

BME 672. Biomaterials. 3 credits, 3 contact hours.
Prerequisite: MECH 320 (see undergraduate catalog for description) or the equivalent. Materials and processes used to develop devices that are implanted in the human body; clinical aspects of biomechanical engineering; federal government requirements for design and testing of human implant devices; biocompatibility, metal implant devices, material design parameters, plastic and ceramic devices, sterilization techniques, and their effect on biocompatibility.

BME 673. Biorobotics. 3 credits, 3 contact hours.
Basics of control of a robot and telemanipulation are studied. Computer simulations, MATLAB are used to explore biomimetic autonomous robots. This is a studio-based course with hands-on exercises with small robots and actuators. Topics include understanding how biological robots (humans and animals) differ from designed robots, as well as sensors (touch, stereo and position), actuators (muscles, smart materials), and intelligent (neural and computer controlled systems.

BME 674. Principles of Neuromuscular Engineering. 3 credits, 3 contact hours.
Neurophysiology, motor control and robotics are used to study the human motor system. Sensorimotor learning and acquisition of new motor skills are emphasized. Topics include the central nervous system, muscle properties, spinal motor circuitry and dynamics of limb motion. The relation of motor control problems to neurophysiology of the motor system and how motor disorders affect movement control are studied. MATLAB and Simulink are used in simulations and movement date analysis.

BME 675. Computer Methods in Biomedical Engineering. 3 credits, 3 contact hours.
This course uses MATLAB to concentrate on methods that allow students to produce original software that can be used to acquire, process, analyze and present data. Topics include advanced graphics and animation, graphical user interfaces, interfacing to and data acquisition from laboratory instrumentation, filtering and processing of acquired data, and interfacing to user interfaces (e.g. joysticks). Applications in speech, bioelectrical signals, images and virtual reality will be included.

BME 676. Computational Biomechanics. 3 credits, 3 contact hours.
Prerequisites: BME 670 or equivalent. The use of commercially available software to solve complex engineering problems has become standard practice to reduce time and cost and results in a better product. This is an intro course on computational methods and the use of commercial software such as ANSYS, Fluent, and MATLAB to solve problems related to the BME device industry. Suitable for students interested in Computer Aided Design and Engineering (CAD/CAE).

BME 677. CAD for Biomechanics and Biomaterials. 3 credits, 3 contact hours.
Introduction to Computer Aided Design theory and application using software. Topics include datum planes, extrude, cut, sweep, swept cuts, and parallel, rotational, and general blends. Assemblies and generating, dimensioning, editing, and modifying drawing views and creation of balloons, imaging and scanning techniques of anatomical structures such as bone and arteries and 3D printing are also covered.

BME 678. Design of Orthopedic Implants. 3 credits, 3 contact hours.
Prerequisite: BME 677. First of a two part course on design of orthopedic implants using ProEngineer. Additional topics include machanical properties of implant materials, material selection and introduction to FEA. Methods for prototype development with the use of 3D printing will also be discussed. A critical objective of this course is the preparetion of design reports and project presentations.

BME 679. Advanced Design of Orthopedic Implants. 3 credits, 3 contact hours.
Prerequisites: BME 677, BME 678 or equivalent. Advanced modeling techniques for the design of hip, knee, and spine implants. Mechanical properties of materials, including wear and failure modes associated with typical implants. Kinematics and surgical protocols of implants will be discussed. Course will cover assemblies and FEA analysis of implants. Additional topics include large deformations, fatigue, optimization, review and analysis of results.

BME 680. BioMEMS Design and Applications. 3 credits, 3 contact hours.
The advance of bioMEMS (Micro Electrical Mechanical Systems) technology is a key component in making the next generation medical diagnostic tools possible. We will learn how bioMEMS devices are fabricated and combine engineering analysis with knowledge of known biological responses and biomolecule interactions to understand how bioMEMS are designed and function. Topics will include biological, mechanical, electrical, and chemical biosensors, and microfluidics as applied to biotechnology.

BME 682. System Mgmt for Medical Device. 3 credits, 3 contact hours.
This course will provide a detailed overview of Project Management techniques and methods applied to medical devices and show the integration of medical device Design Controls from 21 CFR820.30. General knowledge from the field of Project Management will be conveyed from the perspective of engineering or science personnel in the industrial medical field, particularlywith regard to FDA Quality System Regulations (QSR), ISO 13485 guidelines, and Good Clinical Practices (GCP's) for running clinical trials. Students will also take part in practical problem solving simulations based on real-world examples of medical device project anomalies. The combination of specialized project management knowledge for a heavily regulated area and realistic classroom simulation will provide a basis for those interested in commercial medical device development.

BME 684. Medical Device Development. 3 credits, 3 contact hours.
This course will provide a detailed overview of medical device development from a realistic industrial and academic perspective. The processes used in corporations and academic laboratories to conceive and develop devices will be explored from a research, regulatory, clinical, QA/QC, marketing, engineering, and legal perpective under the umbrella of project management techniques. Material will be presented as an aide to students who wish to decide on careers in either industry or academia.

BME 686. Intro. to Instrumentation for Physiomeasurements. 3 credits, 3 contact hours.
Introduction to instrumentation for students without instrumentation background only. This course teaches the hardware and instrumentation needed to measure variables from different physiological systems. Electrodes, sensors and transducers, bioelectric amplifiers safety and digital acquisition will be discussed. Hardware for measurement of the ECG, EEG, EMG, respiratory system, nervous system, clinical laboratory instruments, electrical safety and computers in biomedical instrumentation.

BME 687. Design of Medical Instrumentation. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electronics. Principles and practice of medical instrumentation. Instrument components and medical instrument systems design. Examples taken from electrocardiography, clinical chemistry, medical imaging. Microprocessor-based systems emphasized.

BME 688. Virtual Biomedical Instrument. 3 credits, 3 contact hours.
Introductory course to the programming language, LabVIEWTM. Topics include loops, arrays, clusters, data acquisition, and file input/output. Students will learn how to apply these basic concepts into the development of algorithms. Examples relevant to the biomedical industry will be given how to debug and solve complex programming problems. By the completion of the course, students will be able to develop programs to automate processes and experimental designs.

BME 698. Selected Topics. 3 credits, 3 contact hours.
Selected topics for Biomedical Engineering.

BME 700. Master's Project. 0 credits, 0 contact hours.
Prerequisite: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 700B. Master's Project. 3 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 701. Master's Thesis. 6 credits, 0 contact hours.
Prerequisite: written permission from thesis advisor. Projects include design, construction, experimental or theoretical investigation of the engineering applications to the diagnosis and/or treatment of disease. Research may be in cooperation with industry or medical institutions. Completed work should be of sufficient quality to be acceptable for publication. Oral presentations are required.

BME 701B. Master's Thesis. 3 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 701C. Master's Thesis. 6 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 725. Independent Study I. 3 credits, 3 contact hours.
Restriction: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count BME 725 as degree credit but can count these credits to qualify for full-time status.

BME 726. Independent Study II. 3 credits, 3 contact hours.
Restriction: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count BME 725 as degree credit but can count these credits to qualify for full-time status. This course is not available to master's students.

BME 741. Basic Plasma Physics with Spac. 3 credits, 3 contact hours.
Prerequisites: Phys 611, 621 or other equivalent, or approval of the instructor. The course will introduce students to basic concepts of plasma physics and its applications to laboratory experiments and space research. The course will cover the following topics: particle motions in magnetic field, adiabatic invariants, magnetic traps, radiation belts, electromagnetic waves in plasma, electrostatic oscillations, waves in magnetized plasma, collisional processes in plasma, kinetic effects on plasma waves, Landau damping, wave instabilities, plasma as fluid, magnetohydrodynamics, magnetic configurations of laboratory and space plasma, MHD instabilities, reconnection, helicity, dynamo theories, the origin of cosmic magnetic fields, stochastic processes, Fermi process, particle acceleration, and cosmic rays.

BME 760. Modeling in Func Brain Imaging. 3 credits, 3 contact hours.
Prerequisites: Although no prerequisites are required, BME 310, ECE 640 or other undergraduate and graduate courses covering knowledge on signals and systems in discrete time domain are suggested to prepare for this course. This course will focus on introducing biomedical computing techniques needed for functional MRI data pre-processing, and individual-level and group-level analyses. Several projects will be assigned for hands-on training in implementing the introduced knowledge.

BME 772. Adv Biomats for Lab and Clinic. 3 credits, 3 contact hours.
Prerequisite: BME 672 or equivalent. Background in Materials Science is encouraged. Advanced course on the design, characterization and clinical/research performance of biomaterials that have or may receive acceptance in medicine or as a biomedical research tool. The course requires the student to integrate background in chemistry, physics, cell and molecular biology, tissue engineering and materials science to review and summarize the scientific rationale for materials that have gained acceptance as medical devices, cell culture or diagnostic tools.

BME 774. Principles of Neurorehabilitation. 3 credits, 3 contact hours.
This is a research-focused course providing in-depth review of current studies in the following fields: Pathophysiology of disability; Advanced therapeutic interventions; Emerging neurorehabilitation technologies that are intended to encourage neural reorganization and relearning; Novel interfaces through chronic implementation in the brain, spinal cord and muscles used in deep brain stimulation, brain-machine interfaces, and functional electrical stimulation and Methods of assessing outcomes.

BME 788. Selected Topics. 3 credits, 3 contact hours.
Selected topics for Biomedical Engineering.

BME 790. Doctoral Dissertation. 0 credits, 0 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790C. Doctoral Dissertation. 6 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790D. Doctoral Dissertation. 9 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790E. Doctoral Dissertation. 12 credits, 12 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790F. Doct Dissertation & Research. 15 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 791. Graduate Seminar. 0 credits, 0 contact hours.

BME 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Restriction: Permission of the department. For students admitted to the program leading to the Ph.D. in Computer Engineering or Electrical Engineering. Research carried on under the supervision of a designated member of the department faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under BME 790 after the student fulfills requirements of doctoral candidacy.

CE 501. Introduction to Soil Behavior. 3 credits, 4 contact hours.
Prerequisites: MECH 320, MECH 235 with a grade of C or better and MECH 236 with a grade of C or better(see undergraduate catalog for descriptions). Open only to the students in bridge program. Permission from CEE department graduate advisor is required. Covers the necessary concepts in strength of materials, geology and soil mechanics required for the bridge program in M.S. in Environmental Engineering and Geoenvironmental Engineering option.

CE 502. Civil Construction Methods. 3 credits, 3 contact hours.
Prerequisites: PHYS 111 and MATH 112, or equivalents Open only to students in Online M.S. in Civil Engineering, Construction Management Option. Covers essential concepts in civil and construction engineering including site surveys, construction materials, and soil behavior to partially satisfy bridge requirements.

CE 506. Remote Sensing of Environment. 3 credits, 3 contact hours.
Prerequisite: PHYS 234 (see undergraduate catalog for description). Covers the principles of remote sensing, general concepts, data acquisition procedures, data analysis and role of remote sensing in terrain investigations for civil engineering practices. Data collection from airborne and satellite platforms will be emphasized. Photographic and non-photographic sensing methodologies will be covered as well as manual and computer assisted data analysis techniques for site investigations and examination of ground conditions.

CE 531. Design of Masonry and Timber Structures. 3 credits, 3 contact hours.
Prerequisite: CE 332 (see undergraduate catalog for description). Study of basic properties of clay and concrete masonry units and wood. The masonry segment includes discussion of unreinforced bearing walls subjected to concentric as well as eccentric loads. Lateral-force resistance of unreinforced and reinforced masonry systems are introduced and new developments to strengthen and retrofit unreinforced masonry walls are discussed. The timber design portion includes design and behavior of wood fasteners, beams, columns, and beam-columns as well as introduction to plywood and glued laminated members.

CE 552. Geometric Design of Transportation Facilities. 3 credits, 3 contact hours.
Prerequisite: CE 350 or equivalent (see undergraduate catalog for description). Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. Same as TRAN 552.

CE 553. Design and Construction of Asphalt Pavements. 3 credits, 3 contact hours.
Importance of designing proper asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. Same as TRAN 553.

CE 590. Grad Coop Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from the civil engineering department and the Division of Career Development Services. Cooperative education/internship providing on-the-job reinforcement of academic programs in civil engineering. Work assignments and projects are developed by the co-op office in consultation with the civil engineering department; and evaluated by civil engineering faculty co-op advisors.

CE 591. Grad Coop Work Experience II. 1 credit, 1 contact hour.
Restriction: permission from the civil engineering department and the Division of Career Development Services.

CE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: permission from the civil engineering department and the Division of Career Development Services.

CE 593. Graduate Co-Op Work Exp IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CE 602. Geographic Information System. 3 credits, 3 contact hours.
Restriction: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control. Introduces this emerging technology and its applications. Same as MIP 652 and Tran 602.

CE 605. Research Methods in Remote Sensing. 3 credits, 3 contact hours.
Prerequisites: CE 601 and MATH 661. Major components of RS data acquisition systems, overview of image processing techniques with emphasis on neural network and traditional pattern recognition, principal component transformations, and data reduction. Emphasizes geometric and mapping aspects of RS/GIS techniques for linking RS images with spatial data, sources of error, and accuracy assessment techniques. Hands-on experience with existing hardware/software (ERDAS & GENESIS).

CE 606. Geospatial Data Applications. 3 credits, 3 contact hours.
Prerequisite: CE 602. The course focuses on geospatial data processing, information extraction and analysis tools. It provides visualization and decision support applications using desktop GIS software. Examples of the student projects include: Applications of integrated geospatial date in environmental, infrastructure, urban planning and homeland security.

CE 610. Construction Management. 3 credits, 3 contact hours.
Restriction: B.S. degree in CE, technology, architecture, or related field. Managerial aspects of contracting. Study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning.

CE 611. Project Planning and Control. 3 credits, 3 contact hours.
Prerequisite: CE 610. Management tools as related to construction projects are analyzed and applied to individual projects. Emphasis is on network scheduling techniques, time-cost analysis, resource allocation and leveling, cost estimating, bidding strategy, and risk analysis.

CE 614. Underground Construction. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in soil mechanics. Various aspects of underground construction, including rock and soft ground tunneling; open cut construction; underpinning; control of water; drilling and blasting rock; instrumentation; and estimating underground construction costs. Case studies and a field trip to an underground construction site will be included.

CE 615. Infrastructure and Facilities Remediation. 3 credits, 3 contact hours.
Restriction: graduate standing in civil engineering and basic knowledge of structures, and material science. Examines the methodology of inspection, field testing, evaluation and remediation of existing infrastructure and facilities, which include pipelines, tunnels, bridges, roadways, dams, and buildings. Typical materials distress and failure scenarios will be covered with remediation options through the use of case studies.

CE 616. Construction Cost Estimating. 3 credits, 3 contact hours.
Prerequisite: CE 610. Full range of construction cost-estimating methods including final bid estimates for domestic building and heavy/highway projects; computerized takeoff and estimating techniques; international construction; financial and cost reporting; databases; indices; risk; competition; performance; and profit factors.

CE 617. Historic Preservation. 3 credits, 3 contact hours.
This course addresses the many aspects of structural preservation from both an engineering and aesthetic perspective. Course topics include: permits and regulations, an overview of architectural styles, designation of historic structures, past methods of construction, current methods of preservation and the availability of grants and funding. Knowledge gained from the course will be applied directly to course projects involving the evaluation and recommendations needed for the proposed preservation of an existing structure.

CE 618. Applied Hydrogeology. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in earth science/geology, fluid mechanics, and calculus or permission of instructor. Examines ground water and contaminant movement through the subsurface environment. A basic understanding of the aquifer geology is emphasized. Hydrogeologic applications including well design, pumping tests, and computer modeling of subsurface flow, and methods to monitor and remediate contaminated groundwater are introduced.

CE 620. Open Channel Flow. 3 credits, 3 contact hours.
Prerequisite: undergraduate fluid mechanics. The principles developed in fluid mechanics are applied to flow in open channels. Steady and unsteady flow, channel controls, and transitions are considered. Application is made to natural rivers and estuaries.

CE 621. Hydrology. 3 credits, 3 contact hours.
Prerequisite: undergraduate fluid mechanics. The statistical nature of precipitation and runoff data is considered with emphasis on floods and droughts. The flow of groundwater is analyzed for various aquifers and conditions. Flood routing, watershed yield, and drainage problems are considered.

CE 622. Coastal Engineering. 3 credits, 3 contact hours.
Prerequisite: fluid mechanics and calculus. An introductory course covering basic wave theory, sediment transport and ocean circulation. The application of these principles to various coastal engineering problems will be discussed, including beach erosion, pollution transport in coastal waters, and the design of shore protection structures.

CE 623. Groundwater Hydrology. 3 credits, 3 contact hours.
Prerequisites: undergraduate fluid mechanics and computer programming, or consent of instructor. Basic principles of groundwater hydraulics; Darcian analysis of various aquifer systems; unsaturated flow into porous mediums; transport of contaminants in soil media; and mathematical models for fluid and contaminant transport.

CE 630. Matrix Analysis of Structures. 3 credits, 3 contact hours.
A review of matrix operations and energy methods, and development of flexibility and stiffness methods used in linear-elastic structural analysis. Behavior of continuous beams, plane trusses, space trusses, and frames are studied.

CE 631. Advanced Reinforced Concrete Design. 3 credits, 3 contact hours.
Prerequisites: an undergraduate course in theory and design of reinforced concrete. A review of basic concepts of elastic and ultimate strength theories and a study of the present design codes. Topics include: design of concrete building frames, two-way slabs, flat slabs, deep beams, and other structural elements using the above two theories.

CE 632. Prestressed Concrete Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate course in theory and design of reinforced concrete. Analysis and design of pre-tensioned and post-tensioned prestressed concrete elements for both determinate and indeterminate structures will be studied. Examples of prestressed elements used in buildings and bridges will be discussed, as well as the source and magnitude of prestress losses.

CE 634. Structural Dynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in structural analysis. Dynamic analysis of beams, frames, and other types of structures. Practical methods developed are applied to problems such as the analysis of the effects of earthquakes on buildings and moving loads on bridges.

CE 635. Fracture Mechanics of Engineering Materials. 3 credits, 3 contact hours.
Restriction: graduate standing in civil and/or mechanical engineering and basic knowledge of structures and mechanics of materials. Basic principles of fracture mechanics to increase understanding of cracking and fracture behavior of materials and structures. Emphasis on practical applications of fracture mechanics.

CE 636. Mechanics and Stability of Structures. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in theory of structural analysis. Topics include structural design concept; stability criteria; elastic and inelastic buckling; column buckling; lateral buckling of beams; stability of frames; stability of plates and shell; local buckling and post-buckling.

CE 637. Short Span Bridge Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in steel design and concrete design, and some knowledge of prestressed concrete fundamentals. Design and performance of highway and railroad bridges, particularly steel and prestressed concrete structures since they are most common in the northeast; and computer applications including bridge geometry, abutment design and composite beam design.

CE 638. Nondestructive Testing Methods in Civil Engineering. 3 credits, 3 contact hours.
Familiarizes the civil engineering student with nondestructive testing (NDT) techniques currently employed for evaluation and condition monitoring of civil structures and construction materials. Major emphasis in the application of NDT methodologies to steel, concrete, and timber as the construction material. Covers theories, principles, and testing methodologies associated with individual technologies from specific material point of view. Discusses advantages and limitations pertaining to the application of individual NDT technologies to construction materials.

CE 639. Applied Finite Element Methods. 3 credits, 3 contact hours.
Prerequisites: CE 332 and CS 101. Introduction to application of finite element method to problems of structural analysis and design. Review of matrix algebra and the stiffness method of structural analysis. Applications include trusses, frames, plates, shells, and problems of plane stress/strain. Application of finite element method to design.

CE 641. Engineering Properties of Soils. 3 credits, 3 contact hours.
Prerequisite: approved undergraduate course in soil mechanics within last five years. An in-depth study of physical and mechanical properties of soils. Topics include clay mineralogy, shear behavior and compressibility of fine and coarse grained soil; and in-situ measuring techniques such as vane shear, core penetration and pressure meter. Laboratory work includes consolidation test and triaxial test, with emphasis on analysis, interpretation and application of data to design problems.

CE 642. Foundation Engineering. 3 credits, 3 contact hours.
Prerequisites: approved undergraduate courses in soil mechanics and foundation engineering. The salient aspects of shallow foundation design such as bearing capacity and settlement analyses. Topics are relevant to the deep foundation, selection of the type and the determi-nation of load bearing capacity from soil properties, load tests, and driving characteristics utilizing wave equation analyses. Earth pressure theory and retaining wall design.

CE 643. Advanced Foundation Engineering. 3 credits, 3 contact hours.
Prerequisite: CE 642. Lateral and earth pressure computations for the design of retaining walls, bulkheads, cellular cofferdams, and sheetpiles. Also considers the design of internal bracing systems and anchors, soil nailing and reinforced earth. Slope stability of embankments and dams.

CE 644. Geology in Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate course in geology or permission of instructor. Geology has a significant influence on how we plan, design, and construct engineering works. This course examines how the geologic formations underlying a locale will ultimately determine land use, control structure design, and affect construction material availability. Included is a study of the various rock-forming processes and geologic agents that have shaped Earth's surface. The course also explores the role of geologic factors in assessing environmental impacts and natural hazards such as earthquakes, subsiding soils, and landslides. Case study applications and a field trip are included.

CE 645. Rock Mechanics. 3 credits, 3 contact hours.
Prerequisite: CE 342. Restriction: approved undergraduate course in soil mechanics within last five years or permission of instructor. Theoretical and experimental aspects of rock mechanics and rock engineering. Review of laboratory and field rock testing; empirical and analytical methods for describing strength, deformability and conductivity of intact rock and rock masses. Fracture mechanics and mechanics of discontinuous media, including flow through discontinuous media and hydraulic fracturing. Design and analysis of rock slopes, underground structures in rock and foundations on rock. Includes a term paper/design project.

CE 646. Geosynthetics & Soil Imp. 3 credits, 3 contact hours.
Prerequisite: CE 341 (see undergraduate catalog for description). Includes engineering properties of geosynthetics and their application in civil engineering, such as filtration, seepage, and erosion control; subgrade and slope stabilization. Soil improvement topics include preloading, electrokinetic stabilization, soil modification, admixtures and grouting.

CE 647. Geotechnical Aspects of Solid Waste. 3 credits, 3 contact hours.
Prerequisites: CE 341, CE 341A or equivalents (see undergraduate catalog for descriptions). Geotechnical aspects of solid waste such as municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems. Primary emphasis is on municipal wastes.

CE 648. Flow Through Soils. 3 credits, 3 contact hours.
Prerequisite: CE 641. Explains the fundamentals of fluid flow through saturated and unsaturated soils and the use of computer programs for the solution of boundary value fluid flow problems in soils. The first two-thirds of the course are devoted to flow through saturated soils. The topics are mathematical description of flow through soils, solutions for steady state and transient state fluid flow and geotechnical applications. The last one-third is devoted to flow through unsaturated soils. Topics include steady state of transient state fluid flow and a presentation of how these concepts are applied to geoenvironmental problems.

CE 649. Design & Construction of Concr. 3 credits, 3 contact hours.
Importance of designing concrete pavements to resist distress or failure. Topics include the stresses in Rigid Pavement, Traffic and Loading, Material Characterization, Drainage, Pavement Performance, Rigid Pavement Design and Overlay Design.

CE 659. Flexible and Rigid Pavements. 3 credits, 3 contact hours.
Prerequisite: CE 341 or equivalent (see undergraduate catalog for description). Types of rigid (Portland cement) and flexible (bituminous) pavements. Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. Same as TRAN 659.

CE 671. Performance and Risk Analysis of Infrastructure Systems. 3 credits, 3 contact hours.
This course presents a comprehensive systems approach to infrastructure asset management across areas of public and private infrastructure. Topics include the framework of integrated asset management illustrated in transportation, water and wastewater systems, the economic evaluation of infrastructure options, using life cycle cost analysis (LCCA) and cost-benefit analysis (CBA). The elements of performance measurement and modeling, including condition assessment and information management, failure and impact analysis are covered. Decision and risk analysis are covered to enable students to develop a holistic economic, performance and risk analysis approach to infrastructure management illustrated in a term project.

CE 672. Security Management of Critical Infrastructure. 3 credits, 3 contact hours.
This course focuses on the areas of vulnerability assessment and security management of critical infrastructure systems. A review of techniques for facility and network modeling and performance simulation, leads to sector-specific approaches to vulnerability analysis and critical infrastructure protection strategies using a Model-Based Vulnerability Analysis (MBVA). Covered critical infrastructure systems include water supply/environmental, transportation, power and energy systems, SCADA systems, cyber-infrastructure and telecommunications. The course ends with a review of the combined use of multi-criteria analysis techniques, expert heuristic response to scenarios and network analysis techniques in a general framework for vulnerability and security management of infrastructure systems in its key aspects: prevention, warning/detection and event mitigation and response planning and execution.

CE 700. Master's Project. 0 credits, 0 contact hours.
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of civil engineering problems not covered by regular graduate course work is required. A student with an exceptional project in CE 700 may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for CE 701 Master's Thesis. Students must register for 3 credits every semester until the project is completed.

CE 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering. A written report must be submitted to the project advisor. The student cannot register in CE 700B more than once and the incomplete (I) grade is not allowed.

CE 701. Masters Thesis. 0 credits, 0 contact hours.
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester until completion and submittal of an approved document. Credit will be limited, however, to the 6 credits indicated for the thesis.

CE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CE 702. Special Topics in Civil Engineering. 3 credits, 3 contact hours.
Restriction: advisor's approval. Topics of special current interest in civil engineering.

CE 703. Concrete Durability. 3 credits, 3 contact hours.
Prerequisites: Undergraduate course in construction materials or reinforced concrete design, or permission of the instructor. This course will cover the design and maintenance of concrete structures and pavements from a material choice point of view. Students will learn how to design concrete mixtures, choose alternative and sustainable concrete materials, produce concrete specifications, protect concrete from long-term deterioration, and design solutions for repairing existing concrete. Students will learn about the mechanisms and chemistry and concrete deterioration. The following key topics will be covered: cement production, supplementary cementitious materials, mixture design and proportioning, concrete durability, dimensional stability, freeze-thaw attack, sulfate attack, corrosion, alkali-silica reaction, alternative cements, concrete specifications, and concrete construction.

CE 705. Mass Transportation Systems. 3 credits, 3 contact hours.
Prerequisites: CE 625 and TRAN 610 or IE 610. An investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. Same as TRAN 705.

CE 711. Methods Improvement in Construction. 3 credits, 3 contact hours.
Prerequisite: CE 610. Improved methods in construction; various techniques of work sampling and productivity measurement; and current innovations in the construction industry for increasing efficiency.

CE 720. Water Resource Systems. 3 credits, 3 contact hours.
Prerequisites: CE 620, CE 621. A system methodology is applied to the analysis of water resource development and operation. Topics include operational hydrology, water quality criteria, streamflow requirements, resource allocation, and economics. Mathematical models are developed and employed in the evaluation of a case study.

CE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for CE 726 if they have taken CE 725 in a prior semester.

CE 727. Independent Study III. 3 credits, 3 contact hours.
Restriction: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 730. Plastic Analysis and Design. 3 credits, 3 contact hours.
Prerequisite: CE 639. Theory of plasticity applied to structural design. Study of methods of predicting strength and deformation of single and multi-story steel frames in the plastic range. Comparison of plastic and prestressed concrete.

CE 733. Design of Metal Structures. 3 credits, 3 contact hours.
Prerequisites: CE 639 and CE 636. Methods of design of metal structural systems. Topics include combined action of unsymmetrical sections, torsion of open and closed sections, buckling of columns and plates with various end conditions, and design of curved and boxed girders.

CE 734. Design of Tall Buildings and Space Structures. 3 credits, 3 contact hours.
Prerequisites: CE 639 and CE 636. Design of tall buildings and space structures emphasizing framing systems, and recent developments and current research related to the design of such structures.

CE 736. Finite Element Methods in Structural and Continuum Mechanics. 3 credits, 3 contact hours.
Prerequisites: MECH 630 and CE 630. Restriction: a working knowledge of computer programming. Finite element approaches for analysis of plane stress problems, plates in flexure, shells, and three-dimensional solids; and choice of interpolation functions, convergence, and the capabilities of the methods.

CE 737. Earthquake Engineering. 3 credits, 3 contact hours.
Prerequisite: CE 634. Practical design solutions for resisting the damaging effects of earthquake ground motions and other severe dynamic excitations. Factors which control dynamic response in elastic and inelastic ranges, and the nature of severe dynamic excitations. Theories of structural analysis and dynamics, and modern design methodologies on the behavior of structures.

CE 739. Structural Optimization. 3 credits, 3 contact hours.
Prerequisite: CE 639. Application of methods of mathematical programming to problems of optimal structural design. Optimal criteria methods, discrete and continuous systems, and code design will be covered.

CE 742. Geotechnology of Earthquake Engineering. 3 credits, 3 contact hours.
Prerequisite: CE 641. Explains the fundamentals of propagation of the earthquakes through soils to supporting structures and the use of computer programs in the solution of boundary value problems in soils. The first half is devoted to synthesis of earthquakes, mathematical formulation of the problem, measurement of applicable soil parameters, use of computer programs to solve 1-D wave propagation problems in soils with structures. The second half is devoted to soil liquefaction, soil-structure interaction, and design of machine foundations.

CE 753. Airport Design and Planning. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or EM 693 and CE 660. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. Same as IE 753 and TRAN 753.

CE 765. Multi-modal Freight Transportation Systems Analysis. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or equivalent and CE 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. Same as EM 765 and TRAN 765.

CE 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached. Registration for additional credits may be permitted beyond the 6, with the approval of the advisor, to a maximum of 12 credits per semester. If the dissertation is not completed after 36 credits, registration for an additional 3 credits per semester is required thereafter. Registration for 3 credits is permitted during the summer session, hours to be arranged.

CE 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: CE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in CE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

CE 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CE 791. Since the CE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

CE 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: CE 791. Since the CE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in civil engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

CE 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CE 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CE 790F. Doct Dissertation & Res. 15 credits, 3 contact hours.

CE 791. Graduate Seminar. 0 credits, 1 contact hour.
A seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for CE 790 unless requirement is waived, in writing, by the dean of graduate studies.

CE 792. Pre-Doctoral Dissertation. 3 credits, 3 contact hours.
Co-requisite: CE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in civil engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

CE 793B. Professional Project. 3 credits, 3 contact hours.

CHE 501. Fundamentals of Chemical Engineering I. 6 credits, 6 contact hours.
Prerequisites: MATH 222 or equivalent, CHEM 231 or equivalent(see undergraduate catalog descriptions). An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include material and energy balances, thermodynamics, kinetics and reactor design, and staged separation processes. May not be taken for degree credit in any chemical engineering program.

CHE 502. Fundamentals of Chemical Engineering II. 4 credits, 4 contact hours.
Prerequisites: MATH 222 or equivalent (see undergraduate catalog for description), CHE 501 or equivalent. A continuation of CHE 501. An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include fluid mechanics, heat transfer and diffusion-controlled processes. May not be taken for degree credit in any chemical engineering program.

CHE 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

CHE 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services.

CHE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services.

CHE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CHE 599. Methods for Teaching Assistants and Graduate Assistants. 3 credits, 3 contact hours.
Restriction: graduate standing. Required for all chemical engineering teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

CHE 602. Selected Topics in Chemical Engineering I. 3 credits, 3 contact hours.
Restriction: graduate standing. Topics of current interest in chemical engineering.

CHE 603. Separation Process Principles. 3 credits, 3 contact hours.
Prerequisites: CHE 342, CHE 349, CHE 363, CHE 364, CHE 367, CHE 471. The course covers the basic principles of separation with or without chemical reaction in phase equilibrium-based, external field-driven and membrane-based separation processes.

CHE 604. Membrane Separation Processes. 3 credits, 3 contact hours.
Prerequisites: CHE 342, CHE 349, CHE 363, CHE 364, CHE 367, CHE 471. This course covers the science, technology, engineering analysis and design of membrane separation processes, membrane reactors, membrane-based equilibrium separation processes and hybrid membrane processes.

CHE 611. Thermodynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in physical chemistry and thermodynamics, or equivalent. Principles of thermodynamics developed quantitatively to include thermodynamic functions and their application to chemical engineering processes.

CHE 612. Kinetics of Reactions and Reactor Design. 3 credits, 3 contact hours.
Prerequisites: Undergraduate course in chemical engineering kinetics or equivalent. Elements of optimum design for various reactor types, multiple reactions, and temperature effects. Yield and selectivity optimization with emphasis on small-scale pharmaceutical production. Introduction to non-ideal reactor design. Study of various models for catalytic and non-catalytic solid-fluid reactions.

CHE 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy; near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

CHE 623. Heat Transfer. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in heat transfer. Heat transmission applied to practical problems in design. An introduction will include review of conduction, convection and radiation heat transfer modes. Related topics covered will be heat exchangers, types and design principles (including Kern & Bell?s methods), effectiveness, (NTU Design and Rating methods), Fired Heaters, Design & Rating and Cooling Towers, Design & Rating.

CHE 624. Transport Phenomena I. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in fluid mechanics, heat transfer, and mass transfer. A unified treatment of molecular and turbulent momentum, energy, and mass transport. Emphasis is on the mathematical description of physical mechanisms in momentum and energy transport.

CHE 626. Mathematical Methods in Chemical Engineering. 3 credits, 3 contact hours.
Prerequisites: MATH 222 or equivalent undergraduate degree in Chemical Engineering. The purpose of the course is to emphasize the importance of mathematics to chemical engineering practice. Applications of ordinary differential equations, Sturm-Liouville problems arising from partial differential equations, regular Perturbation approaches to some nonlinear systems of chemical engineering interests, use of Laplace transfroms expecially the Residue Theorem for inversions and some numerical methods. It is suggested that students take this course before taking CHE 624.

CHE 627. Introduction to Biomedical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in thermodynamics and differential equations. Introduction to the structure and composition of the body followed by an exploration of the properties of blood and its flow in the cardiovascular system; the body as a heat source and as a series of compartments involved in mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored. Same as BME 627.

CHE 628. Biochemical Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate degree in chemical engineering. The application of chemical engineering to biological processes, biochemical reaction systems, and their technological use. Special attention given to problems in momentum, energy, and mass transport, as well as chemical reaction kinetics in biological systems.

CHE 654. Corrosion. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in Chemistry. Fundamental principles including thermodynamics and kinetics of corrosion; forms of corrosion (e.g. galvanic, crevice and stress); methods of corrosion measurement; high temperature corrosion; and special case histories.

CHE 675. Statistical Thermodynamics. 3 credits, 3 contact hours.
Prerequisites: CHE 611 or permission of instructor. Application of equilibrium statistical mechanics to chemical engineering problems. Basic postulates and relationships of statistical thermodynamics, including the ideal gas, ideal crystal, and virial equation; statistical theories of fluid mixtures and other advanced topics.

CHE 681. Polymerization-Principles and Practice. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in physical or organic chemistry or CHE 503 or equivalent. The course focuses on the structural and synthetic aspects of polymers and examines in detail a number of bench and industrial scale polymerization methods. In addition to kinetics and mechanisms of commercially important polymerization systems, the course examines reactive modification of synthetic and natural polymers and provides an introduction to applicable characterization methods.

CHE 682. Polymer Structures and Properties. 3 credits, 3 contact hours.
Prerequisites: Undergraduate physical chemistry, a materials related course or CHE 503 or equivalent. The course provides an overview of polymer structures and properties and their relationships from the molecular viewpoint to phenomenological descriptions. Topics include thermodynamics of a single molecule, dynamic theory and viscoelasticity of polymers, polymer solids and mechanical properties, rubbers, polymer blends and composites, biological polymers, and special applications. New areas and innovative applications of polymers will be introduced.

CHE 683. Polymer Processing. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in transport phenomena, fluid flow, or heat transfer or approval of graduate advisor. The course provides a systematic approach to the physical phenomena occurring in polymer processing machinery. The synthesis of the elementary steps of polymer processing are shown in relation to the development of extrusion die flow and extrusion products and injection mold flows and molded products. Structural and residual stresses are examined.

CHE 684. Materials and Process Selection for Polymer Product Design. 3 credits, 3 contact hours.
Prerequisites or corequisites: CHE 681, CHE 682, CHE 683 or approval of graduate advisor. The course provides methodologies for designing polymer-based products by considering materials and processing methods. Methods for selecting homopolymers, polymer blends and composites for specific appilcations will be presented in terms of properties, processability, manufacturing methods and economics. Process/structure/property correlations are presented as well as approaches to product design including CAD, prototyping, and strength and failure criteria. Case studies from biomedical, packaging and other applications are discussed.

CHE 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering. A written report must be submitted to the project advisor. The student cannot register in CHE 700B more than once and the incomplete (I) grade is not allowed.

CHE 701B. Masters Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: CHE 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CHE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHE 701C. Masters Thesis. 6 credits, 6 contact hours.
Co-requisite for full-time students: CHE 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CHE 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHE 702. Selected Topics in Chemical Engineering II. 3 credits, 3 contact hours.
Restriction: graduate standing. Topics of current interest in chemical engineering.

CHE 705. Independent Study. 3 credits, 3 contact hours.
Restriction: permission from the graduate advisor (not dissertation advisor) in chemical engineering. Students working on their PhD or MS theses cannot register for this course with their respective thesis advisors. This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHE 706. Independent Study II. 3 credits, 3 contact hours.
Pre-requisite: CHE 705. Restriction: permission from the graduate advisor (not dissertation advisor) in chemical engineering. Students working on their PhD or MS theses cannot register for this course with their respective thesis advisors. This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHE 709. Adv Separation Processes. 3 credits, 3 contact hours.
Prerequisites: CHE 360, CHE 460, CHE 612, CHE 624 and CHE 626 or permission of instructor. Students having a background in undergraduate separations courses will be introduced to advanced concepts in separations. These include: descriptions of separation; forces causing separation in equilibrium, field and membrane separation processes; flux-force relations; chemical potential profiles; role of chemical reactions in separations; four different combinations of directions of force and bulk motions in separators; time-dependent processes. Advanced analysis of important individual separation processes of three types, namely, equilibrium-based, membrane-based and external field-based processes will be carried out.

CHE 710. Adv Membrane Separation Proc. 3 credits, 3 contact hours.
Prerequisites: CHE 460, CHE 603, CHE 624, CHE 626 or permission of instructor. This course will provide advanced treatments of science, technology, engineering analysis and design of the following membrane separation processes: reverse osmosis, nanofiltration, ultrafiltration, dialysis, electrodialysis, Donnan dialysis, liquid membrane permeation, microfiltration, gas permeation through polymeric membranes, pervaporation, membrane-based equilibrium separation processes, membrane reactors and hybrid membrane processes. Membrane structure/function and device design for each technology are of interest.

CHE 714. Micromechanics of Part Tech Pr. 3 credits, 3 contact hours.
Prerequisites: CHE 624 or equivalent Corequisites: PHEN 601 or equivalent (not required but suggested) Presents methodologies for analyzing the macroscopic properties of particulate systems. Includes characterization and processing of particulate systems at the microlevel, predicting macroscopic properties from microlevel models, and analysis of particulate manufacturing processes involving solids processing, such as solids characterization, blending, milling, granulation, tableting, etc. Course includes laboratory demonstrations and a class project involving use of surface modification.

CHE 721. Combustion Reaction Engineering. 3 credits, 3 contact hours.
Restriction: undergraduate degree in Chemical or Mechanical Engineering. Topics related to the engineering of combustion systems will be discussed. These include laminar flames, turbulent combustion, ideal reactor modeling of complex combustion systems, combustion chemistry, heterogeneous combustion and incineration.

CHE 722. Additive Manufacturing & Appl. 3 credits, 3 contact hours.
Prerequisites: CHE 624 and CHE 626 are both prerequisites or can be taken concurrently. Other equivalent courses can be acceptable for non-chemical engineering students with permission of the instructor. This course describes additive manufacturing technologies and current (and emerging) applications of 3D printing. The course will be composed of a lecture and a hands-on laboratory session, during which students will create 3D designs and print functional prototypes.

CHE 724. Sustainable Energy. 3 credits, 3 contact hours.
The course is a project-based advanced graduate course which requires strong background in engineering thermodynamics and transport phenomena. The main goals of this course are to gain an understanding of the cost-benefit ratio of various alternative energy sources and to understand some of the various obstacles associated with current and conventional technologies and industrial applications. Different renewable and conventional energy technologies will be discussed in class. Course materials include biomass energy, fossil fuels, geothermal energy, nuclear power, wind power, solar energy, hydrogen fuel, hydropower, and fuel cells. Students will learn a quantitative framework to aid in evaluation and analysis of energy technology systems in the context of engineering, political, social, economic, and environmental goals.

CHE 725. Transport Phenomena II. 3 credits, 3 contact hours.
Prerequisite: CHE 624 or equivalent. Transport in laminar and turbulent flow: in solids, between phases, and macroscopic transport in flow systems.

CHE 734. Chem Process Dynamic & Control. 3 credits, 3 contact hours.
Prerequisite: CHE 626 or equivalent. Corequisites: CHE 611, CHE 612 or equivalent Mathematical principles of process dynamics and control; derivation and solution of differential equations describing the behavior of typical chemical engineering processing units; and mathematical analysis and design of control systems. Digital and sampled data control systems also discussed.

CHE 750. Environmental Catalysis. 3 credits, 3 contact hours.
Prerequisites: CHE 612 or equivalent. An introduction to catalytic processes used for environmental abatement. The course provides background information necessary to understand environmental catalytic processes. Mobile and stationary pollution abatement technologies are reviewed.

CHE 756. Industrial Catalysis. 3 credits, 3 contact hours.
Prerequisites: CHE 612 or equivalent. The class provides an introduction to catalytic phenomena as well as catalysts with the background information necessary to understand industrial catalytic processes. Examples discussed are hydrogen, ammonia and methanol synthesis, inorganic and organic oxidation reactions, petrochemical processes, pollution abatement and other important processes. The course provides insight into the theory of catalytic phenomena and information about related technologies from an industrial perspective.

CHE 775. Molecular Simulations in CHE. 3 credits, 3 contact hours.
Prerequisites: CHE 611 and CHE 626. Minimal programming experience in any programming language (e.g. Matlab, Python or Fortran). The course is aimed to introduce graduate students to the basics of molecular simulation. Two simulation techniques will be discussed in detail: Monte Carlo and molecular dynamics methods. The students will study the algorithms, and the statistical mechanics basis of these algorithms. Then they will use popular open source codes to simulate systems relevant for chemical engineers.

CHE 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Co-Requisite: CHE 791. For students admitted before Fall 2015. Required of all students for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

CHE 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have passed the Qualifying Examination and Research Proposal. Required of all students for the degree of Doctor of Philosophy. Approval of dissertation advisor is necessary for registration. Experimental or theoretical investigation of a topic in chemical engineering. Students must register for 1 credit of dissertation per semester until a written dissertation is approved.

CHE 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have passed the Qualifying Examination but have not defended Research Proposal. Required of all students for the degree of Doctor of Philosophy. Approval of dissertation advisor is necessary for registration. Experimental or theoretical investigation of a topic in chemical engineering. Students must register for 3 credits of dissertation per semester after passing Qualifying Examination until they successfully defend their Research Proposal.

CHE 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.

CHE 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CHE 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CHE 790F. Dissertation & Res. 15 credits, 3 contact hours.

CHE 790G. Doct Dissertatopm & Resrch. 18 credits, 0 contact hours.

CHE 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all chemical engineering students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

CHE 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite for full time students: CHE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in chemical engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well, for students who have completed the required coursework but have not passed the qualifying examination.

CHE 792C. Pre-Doctoral Research. 6 credits, 0 contact hours.

CHE 794. Professional Presentations for Ph.D. Students. 0 credits, 0 contact hours.
Intended to help students make better technical presentations. Each student is required to make a presentation on a research topic; guest lectures will occur during the semester.

CHE 795. Research Methods for Doctoral. 3 credits, 3 contact hours.
Prerequisites: Doctoral standing in CBPE or permission of the instructor. This course is designed to enhance professional development of our doctoral students in order to significantly increase their research productivity, communications, and leadership skills while preparing them for a successful career. Concepts include setting priorities, time management, and learning best practices in research planning, execution, communication, writing and presentation. Advanced topics include understanding innovation, intellectual property and writing better proposals.

ECE 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from Department of Electrical and Computer Engineering and Division of Career Development Services. Cooperative education/ internship providing on-the-job reinforcement of academic programs in electrical and computer engineering. Assignments and projects are developed by the co-op office in consultation with the electrical and computer engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in the ECE department. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisites: ECE 590 and permission from Department of Electrical and Computer Engineering and Division of Career Development Services. See ECE 590 course description. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: graduate standing and permission from Department of Electrical and Computer Engineering and Division of Career Development Services. See ECE 590 course description. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

ECE 601. Linear Systems. 3 credits, 3 contact hours.
Methods of linear-system analysis, in both time and frequency domains, are studied. Techniques used in the study of continuous and discrete systems include state-variable representation, matrices, Fourier transforms, LaPlace transforms, inversion theorems, sampling theory, discrete and fast Fourier transforms, and Z-transforms. Computer simulation of linear systems is used, and, where feasible, computer solutions are obtained.

ECE 605. Discrete Event Dynamic Systems. 3 credits, 3 contact hours.
Corequisite: MATH 630 or ECE 601 or MNE 603 or equivalent. Covers the theory of discrete event dynamic systems with applications in modeling, control, analysis, validation, simulation, and performance evaluation of computer systems, flexible manufacturing systems, robotic systems, intelligent supervisory control systems, and communication networks. Emphasis on Petri net and automation based approaches.

ECE 610. Power System Steady-State Analysis. 3 credits, 3 contact hours.
Prerequisite: B.S. in EE or ME. Steady-state analysis of power system networks, particularly real and reactive power flows under normal conditions and current flows under faulty conditions. Symmetrical components and digital solutions are emphasized.

ECE 611. Transients in Power Systems. 3 credits, 3 contact hours.
Prerequisite: ECE 610. Transient performance of power systems with lumped properties, interruption of arcs, restriking voltage, re-ignition inertia effects, switching of rotational systems, magnetic saturation in stationary networks, harmonic oscillations, saturated systems, transient performance of synchronous machines.

ECE 612. Computer Methods Applied to Power Systems. 3 credits, 3 contact hours.
Prerequisite: undergraduate computer programming. Digital computer techniques proven successful in the solution of power system problems, particularly in the electric utility industry. Emphasis on short-circuit, load flow, and transient stability problems. Matrix sparsity is considered.

ECE 613. Protection of Power Systems. 3 credits, 3 contact hours.
Prerequisite: ECE 610 or equivalent Coils, condensers, and resistors as protective devices; fundamental principles of protective relaying; relay operating characteristics; power and current directional relays; differential relays; distance and wire pilot relays; heating and harmonic effects; and Computer-based protective device coordination.

ECE 616. Power Electronics. 3 credits, 3 contact hours.
Prerequisite: B.S. in electrical engineering. Principles of thyristor devices, dynamic characteristics of choppers, commutation, protection, voltage-fed and current-fed inverter drives, cycloconverters, pulse width modulation, phase control, and microcomputer control, with case studies.

ECE 617. Economic Control of Interconnected Power Systems. 3 credits, 3 contact hours.
Economic Control of Interconnected Power Systems: Advanced techniques for operating power systems in the most economic manner while meeting various network constraints; economic dispatch, penalty factors, optimal power flow, short-term electricity markets and locational marginal prices will be studied.

ECE 618. Renewable Energy Systems. 3 credits, 3 contact hours.
This course introduces renewable energy systems. It covers the fundamental concepts of energy and radiation with specific solar energy applications and photovoltaics, electrical energy storage systems, and thermal energy and storage. The second part covers the basic science of wind energy systems and their electrical sytem designs. The third part covers the bioenergy systems from resources to final products and conversion technologies. It finally introduces other promising energy sources.

ECE 620. Electromagnetic Field Theory. 3 credits, 3 contact hours.
Prerequisite: undergraduate electromagnetic field theory or equivalent. Maxwell's equations, boundary conditions and formulation of potentials. LaPlace and Poisson equations for electrostatic and magnetostatic problems and the method of images. Dielectric and magnetic materials, force and energy concepts. Quasi-static and time varying fields, plane, cylindrical and spherical waves. Green's functions, transmission lines.

ECE 622. Wave Propagation. 3 credits, 3 contact hours.
Prerequisite: ECE 620 or equivalent. Fundamentals of electromagnetics; radiation and scattering; Green's functions; integral equations; numerical methods; ray optics and asymptotics.

ECE 624. Optical Engineering. 3 credits, 3 contact hours.
This course covers basic optical concepts, emphasizing those common to many optical instruments, such as light sources and their characteristics, polarization, coherence, and interferometry. The course introduces CAD tools for lenses, optical filters, and instrument design. The course also focuses on topics concerning optical systems, such as flat panel displays and micromechanical optical systems.

ECE 625. Fiber and Integrated Optics. 3 credits, 3 contact hours.
Prerequisite: undergraduate electromagnetic field theory and solid-state circuits. Planar dielectric waveguides, step and graded index fibers and dispersion in fibers. The p-n junction and heterostructures, light emitting diodes and semiconductor lasers, p-i-n and avalanche photodetectors, optical transmitter and receiver designs, optical fiber communication system design concepts.

ECE 626. Optoelectronics. 3 credits, 3 contact hours.
Prerequisite: undergraduate electromagnetic field theory and solid-state circuits. Optical propagation in anisotropic materials, polarization, birefringence and periodic media. Concepts of electro-optics and acousto-optic devices, optical modulators, switches, active filters for optical communication and optical processing.

ECE 630. Microwave Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electromagnetic field theory. Review of transmission line theory and the Smith chart; scattering matrix representation, LC and microstrip matching networks; signal flow graph analysis; micro-wave transistor amplifier design, which includes power gain, stability, noise figure circles; oscillator design.

ECE 632. Antenna Theory. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electromagnetic field theory. Fundamentals of electromagnetic field theory; far field approximation, antenna characteristics (gain, impedance, pattern, etc.); elementary antenna types (dipoles, loops, etc.), antenna array theory, wire antennas; broadband antennas.

ECE 636. Computer Networking Laboratory. 3 credits, 3 contact hours.
Prerequisites: ECE 637 or CS 656. This course provides students with hands on training regarding the design, troubleshooting, modeling and evaluation of computer networks. In this course, students are going to experiment in a real test-bed networking environment, and learn about network design and troubleshooting topics and tools such as: network addressing, Address Resolution Protocol (ARP), basic troubleshooting tools (e.g. ping, ICMP), IP routing (e,g, RIP), route discovery (e.g. traceroute), TCP and UDP, IP fragmentation and many others. Student will also be introduced to the network modeling and simulation, and they will have the opportunity to build some simple networking models using the OPNET modeling tool and perform simulations that will help them evaluate their design approaches and expected network performance.

ECE 637. Internet and Higher-Layer Protocols. 3 credits, 3 contact hours.
The course introduces the protocols and standards of the TCP/IP suite that govern the functioning of the Internet. The material covered in class is a top-down approach on introduction, discussion, and analysis of protocols from the data-link layer to the application layer. Alternative protocols to the TCP/IP suite and new protocols adopted by this suite are discussed. Numerical examples related to network planning and proocol functioning are analyzed.

ECE 638. Network Management and Security. 3 credits, 3 contact hours.
Prerequisites: ECE 683 or CS 652, and ECE 637 or CS 656. Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and from protecting systems for network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms), Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). Same as CIS 696.

ECE 639. Principles of Broadband Networks. 3 credits, 3 contact hours.
Prerequisites: ECE 673, ECE 683 or CS 652 or equivalent. This course covers fundamental concepts of broadband networks. Topics include Broadband ISDN, Switching Techniques, ATM, SONET/SDH, Congestion Control, High-Speed Switching Architectures, Traffic Modeling of Broadband Services, Admission Control, Traffic Scheduling, IP/ATM Convergence, QoS Provisioning in IP Networks, and Optical Networks.

ECE 640. Digital Signal Processing. 3 credits, 3 contact hours.
Prerequisite: ECE 601 or equivalent. The theory of digital signals and basic processing techniques: Discrete Fourier Series, Discrete Fourier Transform and FFT, Linear and Circular Convolution, Digital Filter Design Techniques, Discrete Hilbert Transforms, Discrete Random Signals, Chirp-Z and other advanced transforms. Introduction to multivariate signal processing. The typical applications of signal processing tools are discussed and connected to the theoretical foundations.

ECE 641. Laboratory for High Performance Digital Signal Processing. 3 credits, 3 contact hours.

ECE 642. Communication Systems I. 3 credits, 3 contact hours.
Corequisite: ECE 673. Principles of communication theory applied to the representation and transmission of information. Topics include analysis of deterministic and random signals, amplitude modulation, angle modulation, sampling, quantization, PCM, DM, DPCM, geometric representation of signals, error probability, matched filter and correlation receivers and performance analysis of communication systems signal to noise ratio.

ECE 643. Digital Image Processing I. 3 credits, 3 contact hours.
Prerequisite: ECE 601. Introductory course in digital image processing. Topics include image models, digitization and quantization, image enhancement in spatial and frequency domains, image restoration, image segmentation and analysis.

ECE 644. Wireless Communication. 3 credits, 3 contact hours.
Prerequisites: ECE 321 or MATH 333. This course is focused on the technical challenges and solutions to physical and link layer design of wireless communication systems. Course topics include characterization of the wireless channel, the cellular concept, digital modulation techniques, spread spectrum, multiple access techniques including CDMA and OFDMA, diversity techniques. Advanced techniques such as MIMO, 3G and 4G wireless technologies are introduced. Matlab is used for examples and assignments. Team projects based on advanced wireless technologies.

ECE 645. Wireless Networks. 3 credits, 3 contact hours.
Prerequisites: EE 321 or MATH 333, or equivalent (see undergraduate catalog for descriptions). Introduction to wireless network design, management, and planning stages. Topics include demand modeling, radio planning, network optimization, and information handling architecture with emphasis on resource allocation and mobility management aspects. Investigation of signaling load optimizations and internetworking problems.

ECE 650. Electronic Circuits. 3 credits, 3 contact hours.
Prerequisite: senior undergraduate level semiconductor circuits. Methods of analysis and design of linear and digital semiconductor circuits are studied. Topics include low and high frequency models, passive and active biasing techniques, I-C analysis and design, op-amp circuits, and active filters.

ECE 653. Micro/Nanotechnologies for Interacing Live Cells. 3 credits, 3 contact hours.
In this course, we will study technologies and tools available for interfacing live cells from a sub-cellular, single-cell, and multi-cellular (tissue models) approach. We will introduce key concepts of the biology of cells and tissues and will explore the technologies (micro-/nanotechnologies) and tools (sensors and actuators) available for the investigation of cell and tissue biology. Same as BME 653.

ECE 657. Semiconductor Devices. 3 credits, 3 contact hours.
Fundamental principles of solid state materials necessary for understanding semiconductor devices. Topics include crystal structure; energy bands; electron and hole generation, and transport phenomena; generation and recombination processes, and high field effects. P-N junction diode, metal semiconductor contact, and bipolar and metal oxide semiconductor transistors, including switching phenomena and circuit models. Introduction to: photonic devices~light emitting diodes, semiconductor lasers, photodetectors, and solar cells; microwave devices~tunnel and IMPATT diodes, transferred electron devices, and charge-coupled capacitors.

ECE 658. VLSI Design I. 3 credits, 3 contact hours.
Prerequisite: ECE 657 or equivalent. Analysis and design of digital integrated circuits; basic building blocks and dependence on circuit parameters of propagation delay; noise margin; fan-out; fan-in; and power dissipation for circuits of different logic families, including NMOS, CMOS and BiCMOS; subsystem designs in combinational and sequential logic; Memory Systems; HSPICE circuit simulation is used for digital characteristics evaluation. Mentor Graphics Layout design tools are used for chip design.

ECE 659. Fabrication Principles of Electronic and Optoelectronic Devices. 3 credits, 3 contact hours.
Prerequisite: ECE 657 or equivalent. Overview of all major processing steps in fabrication of integrated circuits such as crystal growth, epitaxy, oxidation, diffusion, ion implantation and etching. Formation of thin film structures along with techniques for defining submicron structures. Emphasizes silicon device technology but also includes processing of compound semiconductors such as gallium arsenide.

ECE 660. Control Systems I. 3 credits, 3 contact hours.
Prerequisites: undergraduate course equivalent to EE 333 or ME 305 (see undergraduate catalog for descriptions) and ECE 601 or equivalent or permission from instructor. Introduction to feedback control. Review of state-space analysis. Frequency-domain methods for analysis: Routh-Hurwitz stability algorithms, Root-loci; Nyquist and Bode plots; system ?type.? Controllability and observability. The separation principle and design by pole placement. Linear observers. Optimization of quadratic performance criteria. Elements of random processes. The Kalman filter as an optimum observer. Robustness considerations.

ECE 661. Control System Components. 3 credits, 3 contact hours.
Prerequisite: ECE 660. The theoretical and practical requirements for analog and digital state-of-the-art control system components are covered. Actuators, amplifiers, sensors, encoders, resolvers and other electromagnetic devices are included. A complete system is designed using current vendor catalog data. Problems affecting the system performance are analyzed using measures of functionality, reliability and cost.

ECE 664. Real-time Computer Control Systems. 3 credits, 3 contact hours.
Prerequisite: EE 486 or equivalent (see undergraduate catalog for description). Emphasizes the practical aspects of modern computer control systems. Topics include: Architecture of digital signal processors (DSP) and microcontrollers, real-time data acquisition devices and interface, programming a DSP, review of sampling theorems and properties of discrete-time systems, introduction of control systems theory, design and implementation of parameter optimized controllers, state variable controllers, and cancellation controllers. An experimental project using a TMS320C2x DSP-based data acquisition system is an integral part of this course.

ECE 667. Bio-Control Systems. 3 credits, 3 contact hours.
The course provides an introduction to dynamic and control in biological systems, with particular emphasis on engineering aspects of biological oscillators/waves which govern the basic operations of all living organisms and especially higher order life forms. A combination of theoretical and simulation tools will be applied to analyze the qualitative and quantitative properties of selected biological systems. Feedback and control mechanisms in selected biological systems will be introduced. Same as BME 667.

ECE 673. Random Signal Analysis I. 3 credits, 3 contact hours.
Fundamentals of the theory of random variables. Introduction to the theory of random processes. Topics include functions of random variables, sequences of random variables, central limit theorem, properties of random processes, correlation, spectral analysis and linear systems with random inputs.

ECE 681. High Performance Routers and Switches. 3 credits, 3 contact hours.
The course introduces the different system comprising and Internet routing including the processors for networking function and protocol compliance, switching functions and packet classification for deep-layer inspection capable routers or network appliances. This course material describe the different functions that Internet routers perform and discusses the different approaches used for improving performance of high-end routers. The content includes a discussion on switch architectures.

ECE 683. Computer Network Design and Analysis. 3 credits, 3 contact hours.
Corequisite: ECE 673. Queueing models and state-transition models are introduced to model, design and analyze computer networks. The OSI model, LANS (including token ring, token bus, and Ethernet), and useful network protocols. Emphasis on the physical, data link and network layers. ALOHA, Stop-and-Wait protocol, Go-Back-N protocol, window-flow-control, and shortest-path routing.

ECE 684. Advanced Microprocessor Systems. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in computer architecture and microprocessors, and some experience in assembly language programming. Architecture of advanced microprocessors; CPU architecture, memory management and protection, interrupt and exception facilities, instruction sets, systems aspects including peripheral interfaces, communications ports, and real-time systems.

ECE 689. Computer Arithmetic Algorithms. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in logic design. Data representation, integers, floating point and residue representation. Bounds on arithmetic speed, algorithms for high speed addition, multiplication, and division. Pipelined arithmetic. Hardware implementation and control issues.

ECE 690. Computer Systems Architecture. 3 credits, 3 contact hours.
Prerequisites: ECE 684 and COE 353 (see undergraduate catalog for description) or CS 650. Discusses advanced topics in modern computer systems architecture such as pipelined and superscalar processors, parallel computers (vector, SIMD, MIMD), multithreaded and dataflow architectures, cache and memory hierarchy, and system interconnect architectures. Also discusses relevant system software design issues such as shared memory and message-passing communication models, cache coherence and synchronization mechanisms, latency-hiding techniques, virtual memory management, program partitioning and scheduling. Examples are drawn from real systems.

ECE 692. Embedded Computing Systems. 3 credits, 3 contact hours.
Pre-requisites: ECE 353 (COE) or ECE 684 (EE) and CS 105 (or equivalents). Introduction of the methodology for the design and implementation of embedded computing systems, and its application to real-world problems. Topics include Embedded System Design Process, UML, ARM Instruct Set Architectures, CPU's Hardware Platforms, Software Design and Analysis, Embedded Operating Systems, Real-Time Scheduling, Hardware Accelerators, Distributed Embedded Systems, and Design Methodology and Quality Assurance.

ECE 698. Selected Topics in Electrical and Computer Engineering. 3 credits, 3 contact hours.
Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

ECE 699. Selected Topics in Electrical and Computer Engineering II. 3 credits, 3 contact hours.
See description for ECE 698 above.

ECE 700. Master's Project. 0 credits, 0 contact hours.
Prerequisite: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry may be acceptable. Work is carried out under the supervision of a member of the department faculty. A maximum of 3 credits may be applied to the degree.

ECE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. A written report must be submitted to the project advisor. The student cannot register in ECE 700B more than once and the incomplete (I) grade is not allowed.

ECE 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: written approval of thesis advisor. Projects involving design, construction, experimental or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried on under the supervision of a designated member of the department faculty. Completed work in the form of a written thesis should be of a quality leading to journal publication. The completed thesis must be defended by the student in an open forum and must be approved by a committee of at least three people. A student must register for a minimum of 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

ECE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in ECE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ECE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (ECE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ECE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

ECE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for ECE 726 if they have taken ECE 725 in a prior semester.

ECE 739. Laser Systems. 3 credits, 3 contact hours.
Prerequisite: ECE 620 or permission of instructor. Optical resonators, laser radiation and oscillation. Laser characteristics: semiconductor lasers, gas and glass lasers; mode-locking, Q-switching. Quantum-well lasers, noise; modulation and detection of laser light, optical systems for communication and computation.

ECE 740. Advanced Digital Signal Processing. 3 credits, 3 contact hours.
Prerequisites: ECE 601, ECE 640 and ECE 673. Topics in stationary discrete time stochastic processes; modeling of discrete time processes, Yule-waker equations, aspects of discrete wiener theory; principle of orthogonality, linear predictors; Levinson-Durbin recursion and algorithm, lattice predictors, method of least squares (RLS) algorithm, systolic array implementation of QRD-Ls.

ECE 742. Communication Systems II. 3 credits, 3 contact hours.
Prerequisites: ECE 642 and ECE 673 or equivalents. Principles of digital communication. Topics include fundamentals of information theory, digital modulation techniques, optimum detector receivers for digitally modulated signals, the bandlimited gaussian channel and intersymbol interference, equalization, spread spectrum, CDMA.

ECE 743. Image Data Hiding, Forensics. 3 credits, 3 contact hours.
Prerequisites: ECE 643 or CS 659 or equivalent As we have entered digital world, information forensics and security have become critically important. With digital images as media, this course covers digital watermarking, reversible data hiding, steganography and steganalysis, forensics and counter-forensics, including image tampering detection, classification of double JPEG/MPEG compressions, camera classification from given images, classification of photographic images from computer graphic images, and so on.

ECE 744. Optimization for Communication Networks. 3 credits, 3 contact hours.
Modern communication are required to provide optimal performance in terms of quality-of-service under strict constrains on the utilization of resources, such as spectrum of power. In addition, the emerging paradigm of decentralized communication systems, such as ad hoc and sensor networks, calls for distributed, and possibly competitive, optimization techniques. This course covers the basic analytical and algorithmic tools that enable such centralized and decentralized optimization.

ECE 747. Signal Decomposition Techniques: Transforms, Sub-bands, and Wavelets. 3 credits, 3 contact hours.
Prerequisites: ECE 640 and ECE 673. Multiresolution signal decomposition techniques, transforms, sub-bands, and wavelets. Time-frequency localization properties of multiresolution algorithms. Evaluation and critique of proposed decomposition strategies from compression and performance standpoints. Applications to speech and video compression, and localized feature extraction. These are basic signal processing tools used in diverse applications such as speech and image processing and storage, seismology, machine vision.

ECE 754. Statistical Machine Learning and Pattern Recognition. 3 credits, 3 contact hours.
Prerequisites: Good knowledge of graduate probability, as in ECE 673 or equivalent, and linear algebra; or permission of instructor. This course provides a systematic introduction to machine learning and pattern recognition using information-theoretic performance criteria as guiding principles. Topics covered include linear and kernel models for classification and regression, sample complexity and VC dimension, probabilistic graphical models and approximate inference.

ECE 755. Advanced Topics in Digital Communications. 3 credits, 3 contact hours.
Prerequisites: ECE 642 and ECE 673 or equivalent. Advanced topics in digital communication systems in the presence of intersymbol interference, noise, and fading: modulation and demodulation in the presence of gaussian noise, efficient signaling with coded modulation, trellis decoding, Viterbi algorithm, digital transmission with intersymbol interference, and digital signaling over imperfect channels.

ECE 756. Advanced Topics in Semiconductor Devices. 3 credits, 3 contact hours.
Prerequisite: ECE 657 or permission of instructor. Builds on ECE 657. Covers photonic devices particularly semiconductor laser and photodetectors for optical systems; microwave and other high speed devices; scaled advanced MOS, FET, and bipolar transistors.

ECE 758. VLSI Design II. 3 credits, 3 contact hours.
Prerequisite: ECE 658 (with ECE 657 suggested). Use of CMOS, biCMOS and bipolar semiconductor technology for VLSI design. Digital techniques are emphasized with minor coverage of analog design. Application areas for full custom, gate arrays, standard cell, and compiled designs are compared. Mentor VLSI design tools running on the HP and Sun workstations are used in the course projects for each enrollee. The course attempts to provide a design environment for projects that is similar to that encountered by VLSI designers in industry.

ECE 760. Solid-State Image Sensors. 3 credits, 3 contact hours.
Prerequisites: ECE 601 and ECE 660. Properties of nonlinear systems and basic concepts of stability including small-signal linearization. State plane methods are introduced, with emphasis on controller design for systems that can be represented by second-order approximations. Concepts of equivalent gain, describing function, and dual-input describing function as applied to a large class of nonlinear systems. Representation of linear sampled-data systems in discrete state variable form, stability and performance of discrete-event systems. Full-state feedback, pole placement and observer design. Linear quadratic control and Kalman filtering.

ECE 776. Information Theory. 3 credits, 3 contact hours.
Prerequisites: ECE 642 and ECE 673 or equivalents. Classical theory of information developed from Shannon's theory. Information measure, Markov sources and extensions, the adjoint source, uniquely decodable and instantaneous codes and their construction, Shannon's first and second theorems, mutual information, and performance bounds on block and convolutional codes.

ECE 777. Statistical Decision Theory in Communications. 3 credits, 3 contact hours.
Prerequisite: ECE 642 or equivalent. Relation between detection theory and statistical hypothesis testing problem. Use of Bayes decision criteria, Neyman-Pearson, and mini-max tests; receiver operating characteristics. Representation of signals in signal space, probability of error calculations. Estimation of random and non-random signal parameters, Cramer-Rao Inequality. The general Gaussian problem and the use of covariance matrices.

ECE 783. Computer Communication Networks. 3 credits, 3 contact hours.
Prerequisites: ECE 673 and ECE 683. Data link control and communication channels. Delay models in data networks. Queueing analysis techniques are taught in detail. Multi-access communication techniques. Routing in computer communication networks.

ECE 788. Selected Topics in Electrical and Computer Engineering. 3 credits, 3 contact hours.
Special-area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

ECE 789. Selected Topics in Electrical and Computer Engineering II. 3 credits, 3 contact hours.
See description for ECE 788.

ECE 790. Doctrl Dissrtn & Research. 0 credits, 0 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790A. Doctrl Dissrtn & Research. 1 credit, 1 contact hour.
Co-requisite: ECE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in ECE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

ECE 790B. Doctrl Dissrtn & Research. 3 credits, 3 contact hours.
Co-requisite: ECE 791. Since the ECE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

ECE 790C. Doctrl Dissertation & Resrch. 6 credits, 6 contact hours.
Co-requisite: ECE 791. Since the ECE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

ECE 790D. Doctrl Dissertation & Resrch. 9 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790E. Doct Dissrtation & Resrch. 12 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790F. Doct Dissertation & Resrch. 15 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790G. Doct Dissertation & Resrch. 18 credits, 3 contact hours.

ECE 791. Graduate Seminar. 0 credits, 0.5 contact hours.
All master's and doctoral students must register for two semesters and six semesters of ECE 791 Graduate Seminar, respectively. To receive a satisfactory grade, students must attend at least five seminars during the semester, as approved by the seminar supervisor.

ECE 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: ECE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ECE 792C. Pre-Doctoral Research. 6 credits, 3 contact hours.

EM 501. Industrial Management. 3 credits, 3 contact hours.
Prerequisite: approval from the engineering management graduate advisor or program director. Operational aspects of management techniques: organization, product design and development, distribution logistics, marketing, plant location and layout, materials handling, production planning and control, inventory control, quality control, work analysis, and incentive plans.

EM 502. Engineering Cost Analysis. 3 credits, 3 contact hours.
Restriction: approval from the engineering management graduate advisor or program director. Financial, engineering, economic, and cost-control aspects of industrial management; the accounting cycle; cost accounting procedure; and cost-model techniques of making cost comparisons through engineering economic studies.

EM 503. Methods and Applications of Industrial Statistics and Probability. 3 credits, 3 contact hours.
Restriction: approval from the engineering management graduate advisor or program director, undergraduate course in calculus. An analytical approach to basic engineering probability and statistics, with applications drawn from both manufacturing and process industries. Emphasis is placed upon the utility of statistical inference derived from engineering data.

EM 602. Management Science. 3 credits, 3 contact hours.
Prerequisite: undergraduate calculus and probability and statistics. Linear programming: formulation, methodology, and application; the transportation problem; the assignment problem; Markov chains and their applications in decision making; queueing systems; deterministic and stochastic inventory models.

EM 617. Environmental Risk Assessment. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in calculus and economics. Application of management technique methodology to recognize, evaluate, and make decisions regarding expenditures for the mitigation of potentially hazardous environmental risks. Basic analytical techniques applicable to social and economic risk assessment; methodology and application to current air and water resources; and rationale for cost-benefit and trade-off analysis. Technical characteristics of materials: half-life, decomposition rates, and temperature sensitivity determining environmental probabilities and expectations.

EM 631. Legal Aspects in Environmental Engineering. 3 credits, 3 contact hours.
Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.

EM 632. Legal Aspects in Construction. 3 credits, 3 contact hours.
Introduction to the legal factors affecting construction activities: contract responsibilities of contractors, engineers, and owners; subcontracts and third-party liability; construction law and code compliance; and insurance and bonds.

EM 633. Legal Aspects of Health and Safety. 3 credits, 3 contact hours.
Review of key laws and regulations pertaining to occupational health, safety, and product liability; methods to determine which codes apply in given situations and to prepare operating procedures to be used for internal compliance.

EM 634. Legal, Ethical and Intellectual Property Issues for Engineering Managers. 3 credits, 3 contact hours.
Introduction to various environmental, product liability, health and safety, and intellectual property, legal, as well as ethical, issues facing engineering managers. Current New Jersey and federal laws and pending legal actions in these fields. Case studies and advanced multimedia learning tools are used.

EM 635. Management of Engineering Research and Development. 3 credits, 3 contact hours.
Prerequisites: principles of management and statistics, or EM 501 and EM 503. A systems approach to management of resources, and tasks needed for engineering research and development. Identification, analysis, and evaluation of the operational characteristics and structure of the research laboratory and engineering office; functions of planning, organizing, staffing, direction, control, innovation, and representation; and planning and control theories, techniques, and current practices in scientific and engineering management.

EM 636. Project Management. 3 credits, 3 contact hours.
Prerequisites: IE 492 (see undergraduate catalog for description), IE 603 or equivalents. Introduction to concepts of project management and techniques for planning and controlling of resources to accomplish specific project goals. While the focus is on technically oriented projects, the principles discussed are applicable to the management of any project. Topics include time, cost considerations, cash flow forecasting, financial and performance control, documentation.

EM 637. Project Control. 3 credits, 3 contact hours.
Prerequisite: EM 636 or equivalent. Focuses on the methodology that can be employed to plan project implementation and control progress. Topics include work breakdown construction, task and schedule development budgetary control, earned value analysis, and behavioral considerations. Project management software utilization is emphasized.

EM 640. Distribution Logistics. 3 credits, 3 contact hours.
Prerequisite: EM 602 or TRAN 650 or equivalent. Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. Same as TRAN 640.

EM 641. Engineering Procurement and Materials Management. 3 credits, 3 contact hours.
Prerequisites: EM 602, EM 640, and EM 674 or equivalents. Study of the logistics life cycle, involving planning, analysis, design, testing, distribution and life cycle support. Make versus buy engineering design decision. Various tools and techniques for an effective life cycle support program. Bench-marking approach to survey available internal and external resources and competitor solutions. Constructing life cycle cost models for acquisitions. Build adequate specification. Application of the latest techniques in supplier chain quality management. Case studies and advanced multimedia learning tools are used.

EM 655. Management Aspects of Information Systems. 3 credits, 3 contact hours.
Prerequisite: computer programming experience. Information flow in an organization as an integrated system and management resource: techniques of data analysis, design, and processing; characteristics of computerized information-handling equipment; data acquisition, storage, processing, retrieval, and transmission to decision-makers; and information systems for finance, production, inventory, accounting, marketing, and distribution.

EM 660. Financing an Industrial Enterprise. 3 credits, 3 contact hours.
Prerequisites: undergraduate economics, accounting, and engineering economy. Principles of financial practice and management in modern business corporations emphasizing financial planning and control; capital project and working capital needs; internal and external financing; and finance as a major function of the management process.

EM 661. Advanced Engineering Economics. 3 credits, 3 contact hours.
Prerequisite: undergraduate engineering economics or equivalent. Economic use of a firm's capital resources. Feasibility studies of potential major capital investments likely to be considered by an enterprise. Risk assessment, cost engineering, effect of financing sources, life cycle, and technologies forecasting models. Case studies are used.

EM 674. Benchmarking and Quality Function Deployment. 3 credits, 3 contact hours.
Prerequisite: IE 673 or equivalent. Continuation of IE 673. Benchmarking surveys of competition, process analysis of engineering activities, statistical process control mathematics, Taguchi methods of process and product design, current total quality management innovations, quality functional deployment. Case studies and advanced multimedia learning tools are used.

EM 691. Cost Estimating for Capital Projects. 3 credits, 3 contact hours.
Prerequisites: EM 502 and EM 503, or equivalent. Cost estimating techniques and procedures for budgeting used in evaluation, planning, and control of capital investments. Emphasis on updating for change, escalation, and statistical and computer methods.

EM 693. Managerial Economics. 3 credits, 3 contact hours.
Prerequisite: undergraduate economics. Internal and external influences on the economic practices of business; classical and current theories of economic behavior; contemporary analytical techniques; behavior of costs, prices, and profits; demand analysis, competition and monopoly; capital expenditure planning; profit theories and business cycles; and econometric models of market strategies, competitive action, and demand behavior.

EM 695. Public Utility Energy Management. 3 credits, 3 contact hours.
Prerequisite: EM 602 or equivalent. Managing loads on electric power systems. Influence of variable rate structure and description of several projects currently in progress.

EM 696. Nuclear Power Reactor Management. 3 credits, 3 contact hours.
Prerequisites: undergraduate economics and physics. Nuclear power reactor management and power generation alternatives: optimum performance; maximum control; minimum cost; capacity planning; cost estimating; investment requirements; plant location and safety; separation technology for fuel enrichment; transportation and storage of spent fuel; reprocessing and nuclear waste storage; and regulatory aspects of nuclear power.

EM 700. Master's Project. 0 credits, 0 contact hours.

EM 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in engineering management. A written report must be submitted to the project advisor. The student cannot register in EM 700B more than once and the incomplete (I) grade is not allowed.

EM 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: matriculation for the M.S. degree, adequate graduate courses in the field of the proposed thesis, and the thesis advisor's approval. Thesis must contribute to the field, and preferably aid the candidate's present or potential career. While original research may not always result, the thesis should provide a new conclusion or application. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

EM 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in engineering management that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in EM 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EM 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in engineering management that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (EM 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

EM 714. Multicriteria Decision Making. 3 credits, 3 contact hours.
Prerequisite: some background in operations research. Multiobjective programming and conflict analysis to evaluate alternatives in decision making, utility, assessment methodology, interactive and noninteractive multiple mathematical programming methods, and surrogate worth trade-off methods are covered.

EM 715. Design of an Enterprise. 3 credits, 3 contact hours.
Prerequisites: undergraduate economics, industrial management accounting, engineering economy, probability and statistics; 9 credits of EM courses at 600-level or above; and advisor's approval. Organization and management of an enterprise, from initial planning through production and distribution of manufactured products. Students choose the industry that they study.

EM 716. Seminar in the Design of an Enterprise. 3 credits, 3 contact hours.
Prerequisite: EM 715. Continuation of EM 715. Depending on the student's interest, report on design of the particular enterprise emphasizing either the management of research and development; the management of production; the management of distribution; or the management of manpower.

EM 725. Independent Research. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

EM 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for EM 726 if they have taken EM 725 in a prior semester.

EM 740. Management of Transportation Carriers. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or equivalent and TRAN 650 or EM 602 or equivalent. Presents theory and practice of managing transportation carriers, including the concepts of costing, pricing, designing and marketing transportation service; the concepts of financial efficiency and resource productivity with application to the selected freight carriers in each mode of transportation. Selected case studies of carriers? operations management practices in various modes. Comparative studies of service characteristics, market share, cost structures both within a particular transportation mode and between the modes. Same as TRAN 740.

EM 765. Multi-modal Freight Transportation Systems Analysis. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or equivalent and TRAN 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. Same as TRAN 765 and CE 765.

EM 771. Operations Cost and Management Control. 3 credits, 3 contact hours.
Prerequisites: 6 credits of EM courses at 600-level or above. Analysis and control of cost and other operational aspects of enterprises: manufacturing, distribution and overhead budgets; cost accounting; management information systems; relevant behavioral factors; financial and other management reports. Case studies used.

ENE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

ENE 630. Physical Processes of Env Syst. 3 credits, 3 contact hours.

ENE 660. Introduction to Solid and Hazardous Waste Problems. 3 credits, 3 contact hours.
Prerequisite: ENE 663. (May be taken concurrently.) Introduction to solid waste disposal. Industrial and urban sources of solid waste and conventional methods of waste disposal. Application of engineering principles related to these topics.

ENE 661. Environmental Microbiology. 3 credits, 3 contact hours.

ENE 662. Site Remediation. 3 credits, 3 contact hours.
Prerequisite: EM 631. Can be taken concurrently with EM 631. Examines site remediation from start to finish. Includes regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Examines established and innovative cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.

ENE 663. Water Chemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate general chemistry. The ability to analyze and solve a wide range of chemical equilibrium problems in water chemistry is developed.

ENE 664. Physical and Chemical Treatment. 3 credits, 3 contact hours.
Prerequisite: ENE 663. Physical and chemical operations and processes employed in the treatment of water and wastewater. Topics include gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.

ENE 665. Biological Treatment. 3 credits, 3 contact hours.
Prerequisites: ENE 663, ENE 661. (May be taken concurrently.) Principles of evaluation and control of water pollution that describe aerobic treatment processes: oxidation ponds, trickling filters, and activated sludge. Anaerobic digestion and sludge handling and disposal as well as biodegradability study techniques for various wastes.

ENE 666. Analysis of Receiving Waters. 3 credits, 3 contact hours.
Prerequisites or corequisites: ENE 663 and ENE 661. Ecological responses of various types of receiving waters to municipal and industrial waste loadings. Mathematical models for water quality prediction and planning.

ENE 667. Solid Waste Disposal Systems. 3 credits, 3 contact hours.
Prerequisite: ENE 663. Review and evaluation of design criteria, methods, and equipment employed in handling and disposal of industrial and municipal solid wastes. Emphasis is on hazardous toxic waste, resource recovery, and regulatory constraints.

ENE 671. Environmental Impact Analysis. 3 credits, 3 contact hours.
Prerequisite or corequisite: ENE 663. A graduate course dealing with physical aspects of the environment. Overview of environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.

ENE 672. Stormwater Management. 3 credits, 3 contact hours.
This course provides a comprehensive study of stormwater management with emphasis on design practices. Topics include regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.

ENE 673. Sustainability and Life Cycle Analysis. 3 credits, 3 contact hours.
The course provides a systematic foundation for the connection between evolving technology and human activity impacts on natural systems by emphasizing the sources of environmental degradation and energy use and strategies to reduce risk and promote sustainability. The course provides hands-on experience with life cycle assessment computer tools and approaches. The course emphasizes relationships between industrial activities and regional and global natural systems-physical, chemical and biological-focusing on the importance of sustainability goals and practices.

ENE 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of environmental engineering problems not covered by regular graduate course work is required. A student with an exceptional project in EnE may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for EnE 701 Master's Thesis.

ENE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. A written report must be submitted to the project advisor. The student cannot register in ENE 700B more than once and the incomplete (I) grade is not allowed.

ENE 701. Master'S Thesis. 0 credits, 0 contact hours.
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated for the thesis.

ENE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in ENE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ENE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (ENE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ENE 702. Special Topics in Environmental Engineering. 3 credits, 3 contact hours.
Restriction: advisor's approval. Topics of special current interest in environmental engineering.

ENE 720. Environmental Chemodynamics. 3 credits, 3 contact hours.
Introduction to concepts, mechanisms and models used to describe the transport of chemicals in the environment. Concepts and models are applied to air-water, sediment-water and soil-air interfaces.

ENE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

ENE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for ENE 726 if they have taken ENE 725 in a prior semester.

ENE 790. Doctoral Dissert & Res. 0 credits, 0 contact hours.
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

ENE 790A. Doctoral Dissert & Res. 1 credit, 1 contact hour.
Co-requisite: ENE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in ENE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

ENE 790B. Doctoral Dissert & Res. 3 credits, 3 contact hours.
Co-requisite: ENE 791. Since the ENE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

ENE 790C. Doctoral Dissertation. 6 credits, 6 contact hours.
Co-requisite: ENE 791. Since the ENE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

ENE 790D. Doctoral Dissertation. 9 credits, 9 contact hours.

ENE 790E. Doctoral Dissertation & Res. 12 credits, 3 contact hours.
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

ENE 790F. Doctoral Dissertation & Res. 15 credits, 3 contact hours.
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

ENE 791. Graduate Seminar. 0 credits, 0 contact hours.
Seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for ENE790 unless requirement is waived, in writing, by the dean of graduate studies.

ENE 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: ENE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in environmental engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ENE 792C. Pre-Doctoral Research. 6 credits, 3 contact hours.

ESC 701B. Master'S Thesis. 3 credits, 3 contact hours.

IE 501. Fundamentals of Industrial Engineering. 3 credits, 3 contact hours.
Basic concepts of industrial engineering for students who lack an undergraduate degree in the discipline, including: manufacturing processes, work methods and measurement concepts, basics of human factors, quality control, facilities design, production planning, operations research tools, and simulation models.

IE 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from the industrial engineering program director and the Division of Career Development Services. Cooperative education internship providing on-the-job reinforcement of academic programs in industrial engineering. Work assignments and projects are developed by the co-op office in consultation with the industrial engineering program director. Work assignments are related to student's major and are evaluated by faculty coordinators in the IE department. Course cannot be applied toward degree credit.

IE 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Restriction: permission from the industrial engineering program director and the Division of Career Development Services. Course cannot be applied toward degree credit.

IE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: graduate standing and permission from the industrial engineering program director, and the Division of Career Development Services. Course cannot be applied toward degree credit.

IE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

IE 601. Measurement Methods for Performance Analysis of Operations. 3 credits, 3 contact hours.
Prerequisite: undergraduate mathematics for management science, or EM 602. Quantitative study of various analytical methods for designing and evaluating systems employed in the management of complex enterprises such as decision-making, efficiency measurement, and methods for obtaining optimal system performance.

IE 603. Behavioral Science in Engineering Organization. 3 credits, 3 contact hours.
Prerequisite: undergraduate probability and statistics, or EM 503. A study of scientific research on human behavior in organizations. Processes and problems of communication in engineering activities; line-staff and supervisor-subordinate relationships; formal and informal organizations; organization models; and technical and social structure of organizations.

IE 604. Advanced Engineering Statistics. 3 credits, 3 contact hours.
Prerequisite: IE 331 (see undergraduate catalog for description) or equivalent. The foundations of modern quality improvement, scientific basis of quality engineering, probability, statistical inference, statistical experimental design issues such as randomized blocks, factorial design at different levels, application to factorial design, building models, and implementation and critique of Taguchi's contributions. Statistical software is used in the data analysis.

IE 605. Engineering Reliability. 3 credits, 3 contact hours.
Prerequisite: statistics. Concepts of modern reliability applied to practical industrial problems: statistical concepts, reliability through design, reliability through testing, analysis of reliability data, and the organization and management of a reliability program. Offered alternate years.

IE 606. Maintainability Engineering. 3 credits, 3 contact hours.
Prerequisite: statistics. Factors affecting maintainability design applied to military and industrial problems: statistical concepts; maintainability prediction, allocation, and demonstration; availability, system and costeffectiveness; provisioning; optimal maintenance policies; and management of a maintainability program.

IE 608. Product Liability Control. 3 credits, 3 contact hours.
Product liability and the effect of legal doctrines on minimizing hazards of design and manufacture. Use of actuarial techniques and legal precedents applicable to design, manufacturing, advertising, and marketing problems: warranties, notices, disclaimers, definition of liability, use of expert witnesses, reliability prediction and analysis methods, safety engineering concepts, and design review. A review of government regulations for safety and protection, as well as mandatory and voluntary standards will also be included.

IE 609. Advanced Analytical Engineering Statistics. 3 credits, 3 contact hours.
Prerequisite: IE 604. An extension of the techniques of engineering statistical analysis to industrial applications. Emphasis is placed on the design of experiments and analysis of tests for multivariate level problems.

IE 610. Transportation Economics. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in economics. Principles of engineering economy. Costs of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. Same as TRAN 610.

IE 614. Safety Engineering Methods. 3 credits, 3 contact hours.
Prerequisites: introductory course in statistics and industrial or construction management. Application of selected safety engineering methods to detect, correct, and prevent unsafe conditions and procedures in future practice. Methods selected are from safety management and programs; loss prevention; fire protection; systems safety; the design of buildings and other facilities; and the design of products, machinery, and equipment. Engineering problems in designing and constructing a hazard-free environment.

IE 615. Industrial Hygiene and Occupational Health. 3 credits, 3 contact hours.
Prerequisites: one year of college physics and one semester of college chemistry or biology. Introduction to industrial hygiene. Recognition, evaluation and control of human exposure to noise, heat, bio-hazards, chemicals, radiation, and improper lighting. Government standards, field measurements, work practices, engineering designs, and the effects of excessive exposure on worker health and productivity.

IE 618. Engineering Cost and Production Economics. 3 credits, 3 contact hours.
Prerequisite: IE 502 or equivalent. Cost management of operational activities. Focuses on capital investment decision making and efficient resource utilization to achieve cost-effective operations. Topics include alternative investment evaluation, budgeting activity based costing, quality costs, life cycle management and relevant behavioral science. These are considered in the context of manufacturing and service industry application.

IE 621. Systems Analysis and Simulation. 3 credits, 3 contact hours.
Prerequisites: IE 331, IE 466 (see undergraduate catalog for descriptions), or equivalent or department approval. The application of well-integrated systems approach, systems and systems engineering in the system life cycle, system design process, mathematical tools and techniques applied to systems analysis, design for operational feasibility, systems engineering management, modeling techniques including simulation, application of discrete simulation techniques to model industrial systems, design of simulation experiments using software, output data analysis.

IE 622. Simulation and Risk Analysis in Operations Management. 3 credits, 3 contact hours.
Prerequsite: IE 331 (see undergraduate catalog for description) or equivalent. Introduction to the concepts, methodologies and applictions of simulation in operations management. Foundations of simulation, Monte Carlo approaches, simulation models using spreadsheets, generating probabilistic outcomes using random number generation techniques, applying risk analysis software to spreadsheets for various decisions making. Variety of applications in operations management, finance and marketing. Software to develop models of practical operations management applications, is provided.

IE 623. Linear Programming. 3 credits, 3 contact hours.
Prerequisite: EM 602 or introductory course in operations research. Principles, methodology, and practical applications of linear programming to complex problems in production and marketing, simplex techniques, duality theory, parametric analysis, Wolfe and Dantzig's decomposition methods, ellipsoid method, and Karmakar's method.

IE 624. Heuristic Methods. 3 credits, 3 contact hours.
Prerequisites: EM 503 or equivalent. Techniques and concepts used to develop intelligent decision support systems. Application of rules called heuristics and models of reasoning to solve problems in engineering design and manufacturing. Topics include set theory, fuzzy subset theory, decision theory, logic, inference expert systems and single and multi-fault diagnostics.

IE 641. Operations Analysis. 3 credits, 3 contact hours.
Prerequisites: EM 602 and computer programming experience. Management systems and business behavior using industrial models. Special attention is given to the interaction of individual elements that make up the total system.

IE 642. Network Flows and Applications. 3 credits, 3 contact hours.
Prerequisite: EM 602 or equivalent. Theories, algorithms, computation complexity, and application of networks, shortest path, network flow, and minimum cost flow problems. Models of industrial service systems as network problems.

IE 643. Transportation Finance. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. Same as TRAN 643.

IE 644. Application of Stochastic Modeling in Systems Control. 3 credits, 3 contact hours.
Stochastic processes applied to control of various types of systems: Markov chains, queueing theory, storage theory applications to measure performance of flexible manufacturing systems, telecommunication and distributions networks and similar service systems. Knowledge of probability theory and linear algebra is essential.

IE 650. Advanced Topics in Operations Research. 3 credits, 3 contact hours.
Prerequisite: introductory course in operations research or equivalent. Current topics in deterministic models of operations research: linear programming, large scale decomposition, integer programming, dynamic programming, and nonlinear programming. Emphasis on optimization techniques for solving mathematical programming problems.

IE 651. Industrial Simulation. 3 credits, 3 contact hours.
Prerequisite: introductory course in statistics/simulation or instructor's permission. Statistical design and analysis of Monte Carlo simulation experiments from an engineering view. Examples are provided with emphasis on industrial and manufacturing applications of simulation modeling. Markovian processes simulation, random number generation, mathematical programming, heuristics and decision theory.

IE 652. Facilities Location and Plant Layout. 3 credits, 3 contact hours.
Prerequisite: introductory course in operations research or instructor's approval. Basic con-cepts of facilities location and plant layout. Quantitative and qualitative tools needed in industrial engineering, including single and multiple facilities location problems, site selections and allocation models, use of Duality theory in location and plant layout problem, and computerized layout planning.

IE 653. Facility Maintenance. 3 credits, 3 contact hours.
Prerequisite: EM 501 or equivalent. Intended for those individuals who manage the functioning and maintenance of physical facilities. Emphasis on planning and control of facilities use, maintenance, utility management, managerial control, budgets and costs, personnel administration, legal and safety, flexibility measurement, and design.

IE 655. Concurrent Engineering. 3 credits, 3 contact hours.

IE 659. Supply Chain Engineering. 3 credits, 3 contact hours.
Coordination of product manufacturing and logistic activities across the global supply chain is studied. Focus is on supply chain design, implementation, and control. Topics include transportation and distribution networks, inventory control, demand planning, materials handling and warehousing, supply chain contracts, manufacturing flexibility, product design for responsiveness, and ERP systems. Supply chain analytics concepts and relevant case studies are introduced.

IE 661. Man-Machine Systems. 3 credits, 3 contact hours.
Prerequisite: human factors engineering. Analysis of integrated man-machine systems: physical and psychological effects of systems of deterministic and conditional responses of individuals and groups, and the resulting interaction between individuals, groups, and machine systems; also current research and development pertaining to man-machine systems.

IE 662. Cognitive Engineering. 3 credits, 3 contact hours.
Prerequisite: IE 355 or equivalent. The purpose of this course will be to introduce the application of human factors and cognitive psychology principles to the user interface design of information technology, including computer systems, groupware and communications, handheld devices and Internet applications, and automatic speech recognition interfaces. The course will provide grounding in the engineering design processes used to enhance the usability of products and services, and usability testing methods used by user interface designers. Secondly, major areas and design problems in human-computer interaction and Information Technology will be covered, with real world examples. The course would be appropriate for advanced undergraduates in engineering, computer science, and psychology.

IE 664. Advanced Ergonomics. 3 credits, 3 contact hours.
Prerequisite: IE 355 or equivalent. The course covers important topics for ergonomics, including functional anatomy of the human body, work physiology and body energy expenditure, and biomechanics for people at work. Commonly used analytical tools for ergonomics will be introduced in the course.

IE 665. Applied Industrial Ergonomics. 3 credits, 3 contact hours.
Prerequisites: IE 355 (see undergraduate catalog for description) or IE 699. Introduces the fundamentals and applications of industrial ergonomics for improving equipment, tool, workplace, and job design. Engineers, as well as safety and health professionals, will benefit from the course by understanding the design principles for human operators and current issues in industrial ergonomics, and a variety of evaluating methodologies for the design.

IE 669. Human Design Factors in Engineering. 3 credits, 3 contact hours.
Prerequisite: engineering statistics. Human factors research related to workplace and equipment design and development. Capabilities and limitations of the human sensory-motor system. Design of displays and resulting interaction between individuals, groups, environments and machine systems. Current research in engineering pertaining to the man-machine interface. Not for IE students who have had an undergraduate course in human factors.

IE 670. Industrial Work Physiology. 3 credits, 3 contact hours.
Prerequisite: IE 669 or equivalent. A study of human physiological responses to industrial environmental factors emphasizing knowledge of human anatomy and physiological tolerances: skeletal, muscle, and neuromuscular systems, evaluation of physical work capacity and performance, changes in circulation and respiration during work. Semester project under the instructor's supervision is also required.

IE 672. Industrial Quality Control. 3 credits, 3 contact hours.
Prerequisite: engineering statistics. The management of quality assurance: operational and statistical principles of acceptance sampling and process control; quality problems in production lines, and introduction to total quality management concepts.

IE 673. Total Quality Management. 3 credits, 3 contact hours.
Introduces the concept of total quality management as applicable to industrial systems. Presents methods for product quality improvement. Emphasis is on prevention through quality engineering and design, and goes beyond traditional statistical process quality control. Presentation of recent methods in supplier management, quality assurance, process control, and competitor analysis. Includes Taguchi methods and quality function deployment. Description of ISO 9000 and Baldridge Award.

IE 674. Quality Maintenance and Support Systems. 3 credits, 3 contact hours.
Prerequisites: probability and statistics, IE 331 (see undergraduate catalog for description) or equivalent. Consideration of factors necessary for cost effective maintenance and support of technical operating systems. Topics discussed include service organization and management, spare parts and logistics, quality assurance, ISO9003 training. Examples from automation, computer systems, clinical engineering, power, and transportation will be used to illustrate application areas.

IE 675. Safety in Facility and Product Design. 3 credits, 3 contact hours.
Prerequisite: IE 614 or equivalent. Application of safety principles to minimize the health and safety hazards in the design and manufacture of various products. Practical techniques for, and economic ramifications of, conformance with the many statutes enacted to assure safe workplaces and products.

IE 677. Applied Statistics and Epidemiology for Hazard Analysis. 3 credits, 3 contact hours.
Prerequisite: IE 604 or equivalent. Application of statistical concepts to the field of hazard analysis including: investigation of root causes of accidents, their patterns and trends; rules for systematic data analysis; determination of commonality factors; availability and use of customized computer software.

IE 681. Interdisciplinary Seminar in Occupational Safety and Health. 1 credit, 1 contact hour.
Restriction: OSHE students, or permission of instructor. This is a required course for students who receive the trainee scholarship from the Occupational Safety and Health Engineering Program sponsored by the National Institute for Occupational Safety and Health (NIOSH). Other graduate students are also welcome and encouraged to take the interdisciplinary seminar course. Students and residents in the ERC programs will be able to participate in an interdisciplinary course with students in industrial hygiene, occupational medicine and occupational safety.

IE 682. Industrial Safety and Health Evaluation. 3 credits, 3 contact hours.
Restriction: OSHE students, or permission of instructor. This is a required course for students who receive the trainee scholarship from the Occupational Safety and Health Engineering Program sponsored by the National Institute for Occupational Safety and Health (NIOSH). Other graduate students are also welcome and encouraged to take this site visit course. Upon completion of this course, students will be able to plan and conduct a walk-through evaluation of health and safety hazards in a workplace. Students will also understand the role of occupational health and safety disciplines in the recognition and prevention of occupational injury and illness.

IE 685. Systems Safety. 3 credits, 3 contact hours.
Prerequisites: applied probability/statistics and introductory safety. Safety decision making and systems engineering applications to safety, including planning, managing and conducting system safety programs.

IE 686. Intro to Healthcare Systems. 3 credits, 3 contact hours.
This course provides a systems analysis view of healthcare services, combining economic, quality, enterprise data and activity costing perspectives. Operations, processes and activities that characterize the US Healthcare system are introduced. System costs, reimbursement methods and financial aspects in the healthcare. Focus on the application of information technologies and system engineering tools to effectively create and deliver value in the care process. Analytical tools for identifying opportunities for systems efficiency and effectiveness.

IE 687. Healthcare Enterprise Systems. 3 credits, 3 contact hours.
Prerequisite: IE 686. Provide a thorough understanding of the role of Healthcare Enterprise Systems in healthcare organizations. A detailed study of electronic health records, computerized physician order entry, and meaningful use standards. Design and implementation of enterprise level healthcare information systems, advanced desicion support tools, and process mapping methods for optimal delivery of cost effective care. Analytical and quantitative methods that can be used to evaluate healthcare business processes, determine data requirements, and plan operating procrdures.

IE 688. Healthcare Sys Perfor Modeling. 3 credits, 3 contact hours.
Prerequisite: IE 686. Presents advanced techniques and methods for modeling and evaluating the performance of healthcare systems, including operations research, and productivity analysis, and statistical analysis methods. Introduces the performance dynamics of healthcare systems, identifies key decision variables and formulates their effect on systems performance. Develop and optimize healthcare staffing models. Application of operations research methods to a wide range of healthcare scheduling, facility design and patient flow problems.

IE 699. Special Topics in Industrial Engineering. 3 credits, 3 contact hours.
Restriction: approval from the industrial engineering graduate advisor. Special course given when interest in a subject area develops. Advanced notice of topics will be given before registration.

IE 700. Master'S Project. 0 credits, 0 contact hours.

IE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in industrial engineering. A written report must be submitted to the project advisor. The student cannot register in IE 700B more than once and the incomplete (I) grade is not allowed.

IE 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: matriculation for the master of science degree, thesis advisor's approval, and adequate graduate courses in the field of the proposed thesis. Candidates for the degree who choose this option must submit an acceptable thesis on an approved subject that contributes to the literature of the field, and preferably aids the candidate's present or potential, career. While original research may not always result, the thesis should provide a new conclusion or application. Approval to register for the thesis must be obtained from the thesis advisor. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

IE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in industrial engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in IE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

IE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in industrial engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (IE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

IE 704. Sequencing and Scheduling. 3 credits, 3 contact hours.
Prerequisite: IE 650 or equivalent. Advanced sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems are discussed in this course. Both deterministic and stochastic scheduling models are covered in detail. Heuristics and worst case analysis for unsolvable hard scheduling problems (NP-C problem) are introduced.

IE 705. Mathematical Programming in Management Science. 3 credits, 3 contact hours.
Prerequisites: IE 623 and IE 650. An advanced study of various mathematical programming techniques such as linear and non-linear, parametric, integer, stochastic and dynamic programming. Readings and discussions emphasize mathematical advances and applications in operations research.

IE 706. A Queueing Approach to Performance Analysis. 3 credits, 3 contact hours.
Prerequisite: IE 644 or equivalent. Newly developed techniques in the area of queueing networks that play a critical role in studying several aspects of discrete event stochastic systems such as FMS, computer-aided communication systems, transportation systems and service systems.

IE 725. Independent Research. 3 credits, 3 contact hours.
Prerequisite: approval from the industrial engineering program director. Program of study prescribed and approved by student's advisor. This special course covers areas in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course.

IE 726. Independent Research II. 3 credits, 3 contact hours.

IE 753. Airport Design and Planning. 3 credits, 3 contact hours.
Prerequisite or corequisite: TRAN 610 or EM 693. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. Same as CE 753 and TRAN 753.

IE 754. Port Design and Planning. 3 credits, 3 contact hours.
Prerequisite: TRAN 610 or EM 693. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. Same as CE 754 and TRAN 754.

IE 760. Quantitative Methods in Human Factors. 3 credits, 3 contact hours.
Prerequisite: IE 661. More advanced human factors engineering concepts analyzed quantitatively: systems modeling, control theory, human error, and decision making. Discussion of human factors, research design and data analysis. Operator/computer interaction is also emphasized.

IE 761. Advanced Studies in Human Factors. 3 credits, 3 contact hours.
Prerequisite: one year of graduate work in human factors or the equivalent. The course integrates various areas of graduate studies in human factors such as: work physiology, occupational safety, environment and human-machine systems. Detailed discussion of selected current papers covering theoretical review, experimental design, results, applications, and future research. Completion of semester project under instructor's guidance is mandatory.

IE 762. Psychophysical Methods in Human Factors. 3 credits, 3 contact hours.
Prerequisite: one year of graduate work in human factors or instructor's approval. This course considers various classical and modern psychophysical methods, signal detection theory, information theory, and human information processing applicable to advanced human factors/occupational safety research measurement and normative modeling.

IE 790. Doctoral Dissertation. 0 credits, 0 contact hours.

IE 790A. Doctoral Dissertation. 1 credit, 1 contact hour.

IE 790B. Doctoral Dissertation. 3 credits, 3 contact hours.

IE 790C. Doc Dissertation & Res. 6 credits, 3 contact hours.

IE 790D. Doc Dissertation & Res. 9 credits, 3 contact hours.

IE 790E. Doc Dissertation & Res. 12 credits, 3 contact hours.

IE 790F. Doct Dissertation & Res. 15 credits, 0 contact hours.

IE 790G. Doctoral Dissertation. 18 credits, 0 contact hours.

IE 791. Graduate Seminar. 0 credits, 0 contact hours.
A seminar in which faculty or others present summaries of advanced topics suitable for research. Discussion of research procedures, thesis organization, and content. Students engaged in research will present their own research for discussion and criticism.

IE 792B. Pre Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: IE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in industrial engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ME 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Cooperative education internship providing on-the-job reinforcement of academic programs in mechanical engineering. Work assignments and projects are developed by the co-op office in consultation with the mechanical engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in mechanical engineering. Course cannot be used for mechanical engineering degree credit.

ME 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

ME 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

ME 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

ME 607. Advanced Thermodynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate thermodynamics. Basic laws of thermodynamics are applied to various thermodynamic systems. Topics include: availability, stability requirements, equation of state, property relations, properties of homogeneous mixtures, optimization applied to power generation and refrigeration cycles, and thermodynamic design of system components.

ME 608. Non-Equilibrium Thermodynamics. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics and heat transfer, and ME 616. (May be taken concurrently.) Principles and mathematical techniques of non-equilibrium thermodynamics applied to mechanical engineering problems. Topics include field theory, energy and entropy balances, variational principles, and applications to fluid flow, heat exchangers and combustion.

ME 609. Dynamics of Compressible Fluids. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, fluid mechanics, and thermodynamics. One-dimensional reversible and irreversible compressible fluid flow, including effects of variable area, friction, mass addition, heat addition, and normal shock; two-dimensional reversible subsonic and supersonic flows, and an introduction to the method of characteristics and two-dimensional oblique shock.

ME 610. Applied Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: undegraduate fluid mechanics, thermodynamics, heat transfer and differential equations. Fundamentals of conduction, convection and radiation heat transfer. Practical engineering applications of heat exchangers including the design approaches by Mean Temperature Difference and Effectiveness-NTU methods, fins, convection fouling factors, and variable property analysis.

ME 611. Dynamics of Incompressible Fluids. 3 credits, 3 contact hours.
Prerequisites: undergraduate fluid mechanics and ME 616. (May be taken concurrently.) An introduction to the hydrodynamics of ideal fluids; two-dimensional potential flow and stream functions; conformal mapping; and differential equations of viscous flow. Boundary layer theory and dimensional analysis are introduced.

ME 612. Gas Dynamics. 3 credits, 3 contact hours.
Prerequisite: ME 616. (May be taken concurrently.) Physical phenomena of gas dynamics and mathematical methods and techniques needed for analysis. Dynamic and thermodynamic relations for common flow situations are described through vector calculus. The nonlinearity of resulting equations and solutions such as numerical analysis, linearization or small perturbation theory, transformation of variables, and successive approximations are discussed. The method of characteristics is reviewed in detail for shock flows.

ME 613. Radiation Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, thermodynamics, heat transfer and ME 616. (May be taken concurrently.) Heat radiation of solid bodies, gases and flames; angle factors; radiative properties of electrical conductors and non-conductors; application of radiative networks to multi-body problems; diffuse specular reflectors: artificial satellites and space vehicles; analogy between heat transfer by radiation and electrical networks; and combined conduction and radiation problems.

ME 614. Continuum Mechanics. 3 credits, 3 contact hours.
Prerequisites: Undergraduate courses in mechanics, fluid mechanics, solid mechanics, and mathematics (linear algebra, differential equations, and vector calculus) or approval of the instructor. Fundamentals of the mechanics of continuous media. Specific topics include vector and tensor analysis; kinematics associated with finite deformation; the stress tensor; and the conservation laws of mass, linear momentum, angular momentum, and energy. Constitutive equations for linear and non-linear elastic solids and for inviscid and Newtonian fluids are discussed. The role of material invariance under superimposed rigid body motion and material symmetry in the formulation of appropriate constitutive equations are emphasized.

ME 615. Advanced Mechanical Vibrations. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and system dynamics. One-, Two- and Multiple degree of freedom systems, Lagrange's equation of motion, Runge-Kutta computation, Finite Element Method and classical methods for normal mode analysis, matrix notation and iteration procedure, and Fourier series representation for the solution of vibration problems.

ME 616. Matrix Methods in Mechanical Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate differential equations. Applications of matrix algebra and matrix calculus to engineering analysis; matrix methods in solid and fluid mechanics; vibration, elasticity, viscous fluids, and heat transfer. Matrix theory is used to show the basic unity in engineering analysis.

ME 618. Selected Topics in Mechanical Engineering. 3 credits, 3 contact hours.
Prerequisite: departmental approval. Given when interest develops. Topics may include analysis and/or design of energy or mechanical systems of current interest to mechanical engineers.

ME 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy, near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

ME 620. Mechanics of Materials. 3 credits, 3 contact hours.
Prerequisites: Undergraduate differential equations and mechanics of materials or linear elasticity. Governing equations and other balance laws; stress and strain distributions in solids subjected to various loading conditions; posing and solving boundary value problems for isotropic linear elastic solids; instabilities and other failure modes of linear elastic solids; and numerical techniques to solve the governing equations.

ME 621. Advanced Mechanics of Material. 3 credits, 3 contact hours.
Prerequisites: ME 620. ME 614 is strongly recommended Governing equations and other balance laws for the mechanics of solids; large deformation kinematics and non-linear material behavior; advanced constitutive models for solids; fundamentals of fracture mechanics; numerical techniques for the solution of non-linear solid mechanics problems.

ME 622. Finite Element Methods in Mechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and strength of materials. Using variational formulation and Ritz approximation, element equations for bar, beam, potential flow, heat transfer, torsion of a solid bar and plane elasticity problems are derived and solved with computer programs.

ME 624. Microlevel Modeling in Particle Technology. 3 credits, 3 contact hours.
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first part concerns the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. Same as CHE 625.

ME 625. Introduction to Robotics. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, kinematics and demonstrated competence in computer programming and ME 616. (May be taken concurrently.) Introduction to robotics, and computer-controlled programmable robotic manipulators; robot geometries; kinematics of manipulators; differential motion; work space planning and trajectory control; dynamics; robot sensing, and robot programming.

ME 626. Fatigue Fracture of Solids. 3 credits, 3 contact hours.
A comprehensive introduction to the linear elastic fracture mechanics covering the basics of linear elasticity, crack-tip stress, displacement, and strain fields; energetics of fracture; and fracture toughness testing. This will be followed by a brief introduction to plasticity and elastic-plastic fracture parameters such as J-integral. The state-of-the-art in fracture mechanics, such as cohesive zone models and fracture of emerging materials (e.g., battery materials), will be discussed along with the mechanisms of fracture and toughening in various materials. The course will include assignments and a group project where students undertake critical review of a peer reviewed journal paper on a fracture topic (approved by instructor).

ME 628. Machine Vision Principles and Applications. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and demonstrated competence in computer programming. Fundamentals of machine vision as applied to inspection, recognition, and guidance in mechanical and manufacturing processes. Emphasis on real-time machine vision algorithms for machine parts inspection and identification. Topics include lighting and optics, camera selection and calibration, image segmentation, edge detection, feature extraction, and pattern classification.

ME 630. Analytical Methods in Machine Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, machine design, and ME 616. (May be taken concurrently.) Theory and analytical methods used in machine design. Comparisons are made between approximate and exact engineering methods for evaluation of the range of applicability of solutions. Topics include advanced analysis of threaded members; keyed, splined, and shrink fits when subjected to torque; preloaded bearings; surging, presetting and buckling of coiled springs; and accurate analysis of impact stresses and stresses beyond the yield point.

ME 631. Bearings and Bearing Lubrication. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, machine design and ME 616. (May be taken concurrently.) The theoretical and physical aspects of lubrication: hydrostatic and hydrodynamic problems. Reynold's differential equation for pressure distribution applied to slider bearing and journal bearing problems with and without end leakage.

ME 632. Mechanical Engineering Measurements. 3 credits, 3 contact hours.
This course offers extensive mechanical engineering lab experience, including measurement fundamentals, hands-on experiments, uncertainty analysis, technique comparison, and professional engineering reports. It also focuses on the fundamental principles behind each methodology and relevant applications. The topics cover measurement in major mechanical engineering areas including thermodynamics, thermofluids, and control. Specialized experiments include fluidization, CAD/CAM, and NC machining. Comparisons of experimental results against theoretical or computational results are also required.

ME 633. Dynamics of Machinery. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and matrix analysis. Consideration of kinematics, constraints and Jacobians, linear and angular momentum and potential energy and conservative forces of mechanical systems. Application of principle of virtual work, D?Alembert's principle, method of virtual power and Lagrange's equation to systems of particles and systems of rigid bodies.

ME 635. Computer-Aided Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate linear algebra (matrices operation) and differential equations. Adaptation of computer for solving engineering design problems; design morphology; simulation and modeling; algorithms; problem-oriented languages; use of available software; computer graphics, and automated design.

ME 636. Mechanism Design: Analysis and Synthesis. 3 credits, 3 contact hours.
Prerequisites: undergraduate kinematics, dynamics and demonstrated competence in computer programming and ME 616. (May be taken concurrently.) Kinematic principles combined with computer-assisted methods for designing mechanisms; complex polar notation; and dynamic and kinetostatic analysis of mechanisms. Kinematic synthesis of planar mechanisms; graphical Burmester theory for plane linkage synthesis; and planar linkage synthesis for function and path generation.

ME 637. Kinematics of Spatial Mechanisms. 3 credits, 3 contact hours.
Prerequisites: undergraduate kinematics, dynamics, knowledge of matrices and ME 616. (May be taken concurrently.) Advanced techniques for the dual-number coordinate-transformation matrix modeling to perform the displacement, velocity, static and dynamic force analysis of spatial mechanisms. Applications considered will include shaft couplings, skew four-bars, wobble plates, generalized slider-cranks and robotic manipulators.

ME 638. Computer-Aided Machining. 3 credits, 3 contact hours.
Prerequisites: demonstrated competence in computer programming, ME 305, ME 616 and ME 635 or equivalent. Introduction of computer applications to understand integrated computer-aided machining process. Included in the course are the fundamentals of motion control and NC/CNC/DNC machining, part programming and post-processors, and advances in CAM. Student projects are carried out using appropriate manufacturing software.

ME 641. Refrigeration and Air Conditioning. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, fluid mechanics and thermodynamics. Refrigeration and air conditioning cycles; comfort analysis, psychometric chart analysis, heat and mass transfer steady and transient processes, heating and cooling design loads, energy loads and standards requirements.

ME 643. Combustion. 3 credits, 3 contact hours.
Prerequisites: Undergraduate thermodynamics & fluid mechanics. Chemical & physical process of combustion: ideal combustion, actual combustion, mass balance, energy of reaction, maximum adiabatic combustion temperature, chemical equilibrium, heating values of fuels, combustion in furnaces, internal combustion engines & other heat engines, with emphasis on the analysis & control of the products of combustion in light of environmental considerations.

ME 644. Building Environmental Control Principles. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, fluid mechanics, heat transfer and differential equations. Control systems for buildings including control of temperature, moisture and air quality. Optimization of systems for control of building energy use. Modern microprocessor-based control systems, including direct digital control, proportional and integral controllers, predictive control, adaptive control, optimum start controllers and optimal control.

ME 653. Control of Electro-Mechanical Networks. 3 credits, 3 contact hours.
Prerequisites: undergraduate electrical circuits and mechanical vibrations or equivalent. Electro-mechanical systems; control loops; use of mechanical networks in dynamic systems; and stability and response to various inputs in electro-mechanical networks.

ME 655. Introduction to Modern Control Methods. 3 credits, 3 contact hours.
Prerequisites: undergraduate system dynamics and automatic controls. Introduction to modern control methods applied to mechanical and manufacturing systems. Topics include state variable feedback, observer theory, nonlinear control, optimal control, and adaptive control for both continuous and discrete systems.

ME 660. Noise Control. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and physics. Engineering methods for reducing noise pollution; reduction of intensity at the source; limitation of transmission paths and absorption; application to structures, machinery, ground transportation, aircraft, and noise measurement.

ME 670. Introduction to Biomechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment.

ME 671. Biomechanics of Human Structure and Motion. 3 credits, 3 contact hours.
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

ME 675. Mechanics of Fiber Composites. 3 credits, 3 contact hours.
Prerequisites: ME 315 (see undergraduate catalog for course description) and demonstrated competence in computer programming. Introduces various design problems using fiber composites. Analysis of general fiber composite laminate and short fiber composites, fracture mechanics, fatigue, creep and viscoelasticity, thermal stresses, special layups and associated optimization problems.

ME 676. Applied Plasticity. 3 credits, 3 contact hours.
Prerequisite: ME 620 or equivalent. Fundamentals of plasticity applied to mechanical and manufacturing engineering problems. Topics include elastic-plastic analysis for beams, rings and plates. Plastic instability and slip-line fields are considered.

ME 678. Engineering Design of Plastic Products. 3 credits, 3 contact hours.
Prerequisite: Knowledge of Pro/Engineer (or IDEAS). Structure and properties of plastics including stress-strain behavior and the effect of fillers and reinforcements. Designing for impact, flexure, shear, friction, puncture, creep and fatigue. Case studies of structural, electrical, and optical applications.

ME 679. Polymer Processing Techniques. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in fluid dynamics and heat transfer. Techniques for processing of plastics: extrusion, injection molding, compression molding, thermoforming, casting.

ME 680. Polymer Processing Equipment. 3 credits, 3 contact hours.
Prerequisites: CHE 645 or equivalent and undergraduate heat transfer. Application of heat transfer, fluid mechanics, and thermodynamics to the design and control of polymer processing equipment. Detailed consideration of extrusion, collandering, rotational molding, stamping, and injection molding.

ME 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisite: department approval. An extensive paper involving design, construction, and analysis, or theoretical investigation. Further information may be obtained from the graduate advisor.

ME 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. A written report must be submitted to the project advisor. The student cannot register in ME 700B more than once and the incomplete (I) grade is not allowed.

ME 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: department approval. Projects involving design, construction, experimental, or theoretical investigation carried out under the supervision of a designated member of the mechanical engineering faculty. The completed written thesis must be defended in a publicly announced oral defense. A student must register for a minimum of 3 credits per semester until completion, although degree credit will be limited to the 6 credits indicated for the thesis.

ME 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in ME 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ME 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (ME 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ME 710. Conduction Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: ME 610 and ME 616 or equivalent. Heat transfer by conduction: differential and integral forms of the energy equation for isotropic and anisotropic material. Analytical and numerical studies of transient and steady one-, two-, and three-dimensional heat transfer problems for a variety of boundary conditions including phase change. In addition, variational and boundary element methods are applied to heat conduction problems.

ME 711. Convection Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: ME 610 and ME 616 or equivalent. Development of convective heat transfer theory: currently available methods, analytical and numerical, for predicting heat rates in forced, natural, and mixed convection in laminar and turbulent flow regimes are thoroughly studied. Studied techniques are applied to the thermal design of complex systems.

ME 712. Mechanics of Viscous Fluids. 3 credits, 3 contact hours.
Prerequisites: ME 611 and ME 616. (May be taken concurrently.) Properties and behavior of real fluids in laminar and turbulent motion. Review of tensor analysis; current mathematical and empirical laws and methods; flows in ducts; exact solutions of Navier-Stokes equations; boundary layers over surfaces and flow past bodies.

ME 713. Non-Newtonian Fluid Dynamics. 3 credits, 3 contact hours.
Prerequisites: ME 611, ME616. Review of Newtonian fluid mechanics. Time dependent response and transport properties of non-Newtonian fluids in simple shear and extensional flows. Experimental techniques for measuring dynamic response and transport properties. Continuum and micromechanical constitutive models; solutions of constitutive equations.

ME 714. Principles of Particulate Multiphase Flows. 3 credits, 3 contact hours.
Prerequisite: Courses in fluid mechanics or approval of the instructor. This course provides an introduction to the fundamental principles of mass, momentum and heat transfer in particulate multiphase flows. Theories and governing equations for distinctive responses and motions of each phase and the dynamic interactions among phases are formulated. Typical industrial applications will be illustrated.

ME 717. Selected Topics in Mechanical Engineering I. 3 credits, 3 contact hours.
Prerequisite: department approval. Given when interest develops. Topics may include advanced mechanisms, aerodynamics, analysis of ME systems, design optimization, and case studies in design.

ME 718. ST:. 3 credits, 3 contact hours.

ME 721. Thermal Stresses. 3 credits, 3 contact hours.
Prerequisites: vector analysis or ME 616 or equivalent and theory of elasticity or ME 785. Thermoelasticity; reduction of thermoelastic problems to constant temperature equivalents; fundamentals of heat transfer; and elastic and inelastic stress analysis.

ME 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

ME 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for ME 726 if they have taken ME 725 in a prior semester.

ME 727. Independent Study III. 3 credits, 3 contact hours.
Prerequisites: written permission from department chairperson plus prerequisite courses prescribed by a supervising faculty member. Areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering. A maximum of two independent studies courses may be applied to a degree.

ME 735. Advanced Topics in Robotics. 3 credits, 3 contact hours.
Prerequisite: ME 625. Introduction to advanced topics and techniques in robotics. Subjects covered include differential kinematics, calibration and accuracy, trajectory control, and compliant motion control as well as an in-depth treatment of topics discussed in ME 625.

ME 736. Advanced Mechanism Design. 3 credits, 3 contact hours.
Prerequisites: ME 636 and ME 616. Advanced methods for the synthesis of mechanisms. Topics include synthesis of planar mechanisms for three, four and five positions, multiloop linages, change of branch and order problems, and optimal synthesis of mechanisms. Synthesis of linkages for special types of motion including straight line motion, cusp points on coupler curves and adjustable mechanisms.

ME 738. Computer Aided Engineering. 3 credits, 3 contact hours.
Prerequisites: ME 635. This course covers advanced CAD and CAE tools for visual computing simulation and analysis. Topics include modeling, assembly, CAD data exchange by exporting and importing various CAD model formats, computer simulation and analysis of structure, thermal, fluid and animation of the results of analysis. Multi-physics analyses such as thermal-structure, electric-thermal-structure in MEMS and fluid-structure interactions are studied. The laboratory component involves use of most current commercial CAD/CAE software packages.

ME 752. Design of Plates and Shells. 3 credits, 3 contact hours.
Prerequisites: ME 616 or equivalent and ME 620. A study of plates and shells. Mechanical engineering design solutions for typical loading and boundary conditions through analytical and numerical methods. Plate and shell interfaces and vibration are also considered.

ME 754. Pressure Vessel Design. 3 credits, 3 contact hours.
Prerequisites: ME 616 or equivalent and ME 620. Theories in designing pressure vessels; analysis of circular plates; cylindrical and spherical shells; pressure vessel heads; pipe bends; and attachments. Consideration is also given to pressure vessel materials in fatigue and creep designs.

ME 755. Adaptive Control Systems. 3 credits, 3 contact hours.
Prerequisite: ME 655. Theory and application of self-tuning and model reference adaptive control for continuous and discrete-time deterministic systems. Topics include model-based methods for estimation and control, stability of nonlinear systems and adaptive laws. Applications of adaptive control in mechanical systems and manufacturing processes.

ME 785. Theory of Deformable Solids in Mechanical Engineering I. 3 credits, 3 contact hours.
Prerequisites: ME 616 or equivalent and ME 620. Measure of strain; strain tensor; stress tensor; equilibrium equations; constitutive relations; compatibility conditions; conditions for and formulation of three-dimensional problems; and the relationship of engineering theories for beams, plates, and shells to the equations of elasticity.

ME 786. Theory of Deformable Solids in Mechanical Engineering II. 3 credits, 3 contact hours.
Prerequisite: ME 785. Solutions for problems formulated in ME 785 eigenfunction solutions; operational methods; complex variables theory; three-dimensional problems; contact problems; wave propagation; and non-linear problems.

ME 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Required of all students working toward the Doctor of Philosophy in Mechanical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached and for 3 credits each semester thereafter.

ME 790A. Doc Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: ME 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in ME 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

ME 790B. Doc Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: ME 791. Since the ME 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

ME 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: ME 791. Since the ME 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

ME 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

ME 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

ME 790F. Doctoral Diss & Research. 15 credits, 3 contact hours.

ME 790G. Doctoral Dissertation. 18 credits, 3 contact hours.

ME 791. Graduate Seminar and Professional Presentations. 0 credits, 0 contact hours.
Regular attendance required of all students in the Mechanical Engineering PhD program. Each PhD student is required to make a 15 minute presentation on a topic related to the student's research with an additional 10 minutes to address audience questions. The seminar participants eveluate each speaker.

ME 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: ME 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in mechanical engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ME 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

ME 792D. Pre Doctoral Research. 9 credits, 3 contact hours.

ME 794. Mechanical Engineering Colloquium. 0 credits, 1 contact hour.
Prerequisites: graduate standing and major in mechanical engineering. National and international experts in mechanical engineering discuss their recent research. Required of all students enrolled in mechanical engineering graduate degree programs. Students must register in this course for at least two semesters and attend at least four lectures in each semester. All doctoral students and students with assistantships must register in this course each semester and attend regularly.

MECH 630. Theory Of Elasticity. 3 credits, 3 contact hours.
Prerequisite: differential equations. Theory of elasticity as basis for both advanced stress analysis and for a critical examination of elementary stress analysis.

MNE 601. Computerized Manufacturing Systems. 3 credits, 3 contact hours.
Development of automated manufacturing systems with applications including Industrial Robotics, Programmable Logic Controller, Lean Manufacturing and other artificial intelligence technologies. Laboratory experimentation using hardware and software necessary for various industrial robots & PLC systems in the automotive assemble; pharmaceutical and chemical industries are included.

MNE 602. Flexible and Computer Integrated Manufacturing. 3 credits, 3 contact hours.
Prerequisite: MNE 601. Flexible manufacturing systems are developed including Robotic applications, PLC & CNC programming as automated inspection and transportation systems. Laboratory experience with hardware and software needed for various industrial robots & other automated systems are included.

MNE 654. Design for Manufacturability. 3 credits, 3 contact hours.
Prerequisite: MNE 601 or instructor's approval. Methodologies used in the synthesis and analysis of product design to optimize manufacturability. The relationship of design to production processes, product material, material handling, quality costs, and CAD/CAM are presented. Emphasis is on both formed products and assembled products. Simulation and other design analysis tools are employed.

MNE 655. Concurrent Engineering. 3 credits, 3 contact hours.
Concurrent/simultaneous engineering methods and tools such as system analysis, system modelling and system integration, market oriented, integrated design for manufacturing, assembly, quality and maintenance, product design analysis, integrated product design and manufacturing innovation methods, QFD (Quality Function Deployment) ? applied to concurrent engineering, FMEA (Failure Mode and Effect Analysis), POKA-YOKE, KANZEI, waste reduction, quality circles, rapid prototyping of designed objects and various other advanced processing methods.

MNE 700. Master'S Project. 0 credits, 0 contact hours.
An interdisciplinary team project performed in collaboration with industry. The project must reflect proficiency in the student's selected area of specialization.

MNE 701. Master'S Thesis. 0 credits, 0 contact hours.
In special cases, a thesis based on an important industrial problem will be substituted for the master's project. Research for the thesis should be performed with industrial sponsorship and collaboration.

MNE 725. Independent Study. 3 credits, 3 contact hours.
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in manufacturing computer systems analysis and design in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MNE 791. Seminar In Manufact Engr. 1 credit, 1 contact hour.
A series of invited speakers, primarily from industry, will discuss current manufacturing problems and methods. Attendance at these seminars is required for all students enrolled in the manufacturing systems engineering program.

MTEN 610. Found of Materials Sci & Engr. 3 credits, 3 contact hours.
Prerequisite: Graduate standing. Core course for students in Material Science and Engineering. The effect of structure on the properties and behavior of engineering materials. Topics include atomic structure, bonding, crystallography, and defects in solids; properties of metals, semiconductors, ceramics, and polymers and their behavioral response to mechanical, chemical, optical, electrical, and magnetic stimuli.

MTEN 611. Diffusion & Solid State Kineti. 3 credits, 3 contact hours.
Prerequisite: MTSE 602. The atomic theory of diffusion and mathematical derivation of the diffusion equations. Diffusion phenomena in dilute alloys as well as in ionic and covalent solids are considered. High atom mobility effects at defect sites and surfaces are examined. Chemical kinetics and kinetics of phase transformations including nucleation, growth, and spinodal decomposition are discussed.

MTEN 612. Thermodynamics of Materials. 3 credits, 3 contact hours.
Prerequisite: Undergraduate thermodynamics. Core course for students in Material Science and Engineering. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MTEN 613. Characterization of Materials. 3 credits, 3 contact hours.
Prerequisites: Undergraduate classes covering physics, chemistry, thermodynamics, and heat and mass transfer, or permission of the instructor. The course is designed to introduce graduate students in chemical and materials engineering, and other engineering and science disciplines, to fundamentals and theory of different types of materials characterization tools. Methods and techniques necessary to understand and quantify diverse materials properties will be discussed. As important for many methods, basic principles of interaction of radiation and particle beams with matter will be studied. Topics include, but are not limited to: Diffraction methods; imaging via optical, scanning, transmission electron, scanning tunnelling, and field ion microscopy; microanalysis and spectroscopy, including energy dispersive, wavelength dispersive, Auger methods; secondary ion mass spectroscopy, X-ray photoelectron spectroscopy; materials preparation for analysis, including electron, ion growth, sputtering; thermal analysis: DTA, DSC; and depending on the availability and functionality of equipment, lab visits and demonstrations will be scheduled to the class to discuss some case studies.

MTEN 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials engineering. A written report must be submitted to the project advisor. The student cannot register in MTEN 700B more than once and the incomplete (I) grade is not allowed.

MTEN 701B. Masters Thesis. 3 credits, 3 contact hours.
Co-requisite for full-time students: MTEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in MTEN 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MTEN 701C. Master's Thesis. 6 credits, 6 contact hours.
Co-requisite for full-time students: MTEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (MTEN 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MTEN 711. Nanocomposite Materials. 3 credits, 3 contact hours.
Prerequisites: Core courses in MTSE, MTEN 611 and MTEN 613 or equivalent courses, or permission of the instructor. This course covers advanced aspects of nanocomposite materials formation, properties, characterization, and applications. Emerging materials and their synthesis techniques are discussed along with key issues in processing, as well as identification and characterization of properties as relevant to application areas. Examples include, Polymer-based and Polymer-filled Nanocomposites, Bio-Nanocomposites, Metal and Ceramic Nanocomposites, Nanocomposites for Energy and Electronics materials, etc.

MTEN 712. Nanomaterials. 3 credits, 3 contact hours.
New feature of the 700 level course will be hands-on small projects carried out by groups of two students in Professor Iqbal's laboratories during the second half of the semester. The projects will be selected from the topics covered in the course. A second feature will involve a lecture on a specialized nanomaterial topic given by an invited outside lecturer. This 3 credit interdisciplinary course is designed to teach and provide hands-on project experience to M.S. and Ph.D. graduate students in chemistry, physics/materials science, and chemical/biomedical/electrical engineering on the fundamentals, synthesis, characterization and applications of nanomaterials. 75% of the course will comprise of lectures-one or two of which will be given by invited outside lecturers. 25% of the course will involve small projects based on the syllabus and conducted in the research laboratories of the instructor.

MTEN 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

MTEN 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for MTEN 726 if they have taken MTEN 725 in a prior semester. Students cannot register for this course with the same advisor as they had in MTEN 725.

MTEN 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite for full-time students: MTEN 791. Approval of the dissertation advisor is required for registration. Experimental and theoretical investigation of a relevant topic in materials engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in MTEN 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

MTEN 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite for full-time students: MTEN 791. Since the MTEN 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and theoretical investigation of a relevant topic in materials engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

MTEN 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite for full-time students: MTEN 791. Since the MTEN 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and theoretical investigation of a relevant topic in materials engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities.

MTEN 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Materials Science and Engineering with option in Engineering who have not yet passed Qualifying Examination and Research Proposal. Experimental or theoretical investigation of a topic in chemical engineering. Research is carried out under the supervision of designated chemical engineering faculty.

MTEN 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite for full time students: MTEN 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in materials engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well, for students who have completed the required coursework but have not passed the qualifying examination.

PHB 505. Principles of Pharm. Microbiology and Biochemistry. 3 credits, 3 contact hours.
Prerequisite: Graduate standing. This course covers major concepts of cell biology including cell physiology and structure, molecular biology, and genetics. Cellular chemistry, life cycles, and regulation are discussed as well as the fundamentals of biochemistry related to physical organic chemistry, including buffers, blood proteins, enzymes, carbohydrates, fats, and nucleic acids. This is a required course for PHB students with no or limited knowledge of biology.

PHB 590. Graduate Co-op Work Experience I. 3 credits, 3 contact hours.
Prerequisites: Permissions from Pharmaceutical Bioprocessing Graduate Advisor and Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations at pharmaceutical companies or companies serving the pharmaceutical industry. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

PHB 591. Graduate Co-op Work Experience II. 3 credits, 0 contact hours.
Prerequisites: Permissions from Pharmaceutical Bioprocessing Graduate Advisor and Career Development Services. Same range of activities as in PHB 590. Cannot be used for degree credit.

PHB 592. Graduate Co-op Work Experience III. 3 credits, 3 contact hours.
Prerequisites: Permissions from Pharmaceutical Bioprocessing Graduate Advisor and Career Development Services. Same range of activities as in PHB 590 and PHB 591. Cannot be used for degree credit.

PHB 593. Graduate Co-op Work Experience IV. 0 credits, 3 contact hours.
Prerequisites: Permissions from Pharmaceutical Bioprocessing Graduate Advisor and Career Development Services. Same range of activities as in PHB 590, PHB 591 and PHB 592. Cannot be used for degree credit.

PHB 610. Biotechnology-Biopharmaceutical, Processes and Products. 3 credits, 3 contact hours.
Prerequisites: PHB 505, if required and PHEN 601. This course covers biological processes used in the pharmaceutical and biotechnology industry to obtain pharmaceutical products, including biochemical processes for antibiotic production and peptide extraction, and biopharmaceutical process to obtain recombinant proteins, monoclonal antibodies, cytokines, hormone and blood products, therapeutic enzymes, antibodies, vaccines, and nucleic acid therapeutics.

PHB 615. Bioseparation Processes. 3 credits, 3 contact hours.
Prerequisites: If required, PHEN 500, PHEN 501, PHEN 502 and PHB 505 and PHEN 601. This course covers the principles, methods and unit operations for the separation and recovery of biologically obtained molecules and especially proteins. Also studied here is the relationship between the chemistry of biological molecules and efficient separation and preservation of biological activity, with special emphasis on separation of biomolecules.

PHB 630. Pharmaceutical Bioprocess Engineering. 3 credits, 3 contact hours.
Prerequisites: If required, PHEN 500, PHEN 501, PHEN 502 and PHB 505; PHEN 601. This course covers the principles and methods to develop and operate bioprocess engineering systems, with emphasis on pharmaceutical bioprocessing and the use of chemical engineering principles to obtain products of therapeutic values. Topics include cell line selection, cell growth kinetics, substrate utilization, product formation, transport phenomena in biosystems, and bioreactors.

PHB 698. Special Topics in Pharmaceutical Bioprocessing I. 3 credits, 3 contact hours.
Prerequisites: Graduate standing and permission of the instructor. Topics of current interest in Pharmaceutical Bioprocessing.

PHB 699. Special Topics in Pharmaceutical Bioprocessing II. 3 credits, 3 contact hours.
Prerequisites: Graduate standing and permission of the instructor. Topics of current interest in Pharmaceutical Bioprocessing.

PHB 701. Master's Thesis. 0 credits, 0 contact hours.

PHB 701B. Master's Thesis. 3 credits, 3 contact hours.
Prerequisites: Matriculation in the MS program in PHB and approval of PHB Program Advisor. Original research under the guidance of a Thesis Advisor. A written thesis must be approved by a three-member Thesis Committee including the primary advisor and at least one member of the CBPE faculty. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHB 701C. Master's Thesis. 6 credits, 0 contact hours.
Prerequisites: Matriculation in the MS program in PHB and approval of PHB Program Advisor. Original research under the guidance of a Thesis Advisor. A written thesis must be approved by a three-member Thesis Committee including the primary advisor and at least one member of the CBPE faculty. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHB 725. Independent Study I. 3 credits, 3 contact hours.
Prerequisites: Permission from the Program Advisor in PhB (not the Thesis Advisor), as well as completion of courses prescribed by a supervising faculty member (who cannot be the student's Thesis Advisor). This special course covers areas of study in which one or more students may be interested, but which is not of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

PHB 726. Independent Study II. 3 credits, 3 contact hours.
Prerequisites: Permission from the Program Advisor in PhB (not the Thesis Advisor), as well as completion of courses prescribed by a supervising faculty member (who cannot be the student's Thesis Advisor). This special course covers areas of study in which one or more students may be interested, but which is not of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

PHB 791. Graduate Seminar. 0 credits, 0 contact hours.
Prerequisite: Graduate standing. Required, when offered, of all PHB graduate students receiving departmental or research-based awards. The student must register each semester until completion of the degree, if the Graduate Seminar is offered. Outside speakers and department members present their research for general discussion.

PHEN 500. Pharmaceutical Engineering Fundamentals I. 3 credits, 3 contact hours.
Prerequisite: undergraduate calculus. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree. This course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of calculus, differential equations, probability and statistics, and finance business mathematics applied to pharmaceutical engineering problems and illustrated through pharmaceutical engineering examples.

PHEN 501. Pharmaceutical Engineering Fundamentals II. 3 credits, 3 contact hours.
Prerequisite: If needed, PHEN 500 (which can also be taken concurrently with this course), as well as an undergraduate course in physical chemistry. This course is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of pharmaceutical engineering calculations related to material and energy balances applied to pharmaceutical facilities and systems; estimation of thermophysical properties, phase and reaction equilibrium; and chemical kinetics and basic reactor design.

PHEN 502. Pharmaceutical Engineering Fundamentals III. 3 credits, 3 contact hours.
Prerequisite:If needed, PHEN 500 and PHEN 501, as well as undergraduate course in physical chemistry. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of fluid mechanics, heat transfer, mass transfer and the design of unit operations involving these principles.

PHEN 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations at pharmaceutical companies or companies serving the pharmaceutical industry. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

PHEN 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Same range of activities as in PHEN 590.

PHEN 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Same range of activities as in PHEN 590 and PHEN 591.

PHEN 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisites: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

PHEN 601. Principles of Pharmaceutical Engineering. 3 credits, 3 contact hours.
This course provides an overview of the pharmaceutical industry, including basic information about drug discovery and development, FDA requirements and approval processes, drug dosage forms, and the role of key operational units in drug manufacturing processes. This course enables the students to: understand the role of the pharmaceutical industry in the global market and its implications; learn the fundamentals of the drug development cycle and the investment required to bring a drug to market; learn the most important drug manufacturing processes and the key elements of dosage formulation.

PHEN 602. Pharmaceutical Facility Design. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603; undergraduate courses in differential equations and fluid flow or completion of bridge program for students who are required to take it. This course provides instruction in design of state-of-the art pharmaceutical facilities for both manufacturing and R&D, by identifying key functional requirements and design concepts necessary to pharmaceutical processes. Interdisciplinary training will be provided in appropriate areas of facility design.

PHEN 603. Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems. 3 credits, 3 contact hours.
This course examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving liquid and dispersed-phase systems, such as liquid and multiphase mixing, sterilization and sanitation, lyophilization, filtration, centrifugation and others. The emphasis is primarily on the engineering aspects of the parmaceutical processes examined in the course.

PHEN 604. Validation and Regulatory Issues in the Pharmaceutical Industry. 3 credits, 3 contact hours.
This course is focused on the development of a working knowledge of the Federal Code of Regulations and its impact on the pharmaceutical and allied industries. The history of the Federal Government's regulation of the pharmaceutical industry is studied. Also covered is the industry's response and the methodologies it uses to comply with these regulations.

PHEN 605. Pharmaceutical Packaging Technology. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603, and completion of the bridge program for students who are required to take it. This course focuses on developing a working knowledge of the machinery and unit operations used in transferring a drug substance in the bulk final form to a finished product ready for sale to the consuming public. Packaging of both liquid and solid forms in various types of delivery containers such as vials/ampoules, blister packs, individual packets, bottles, pouches and syringes is examined. The cleaning, sterilization and scaling/capping required for each dosage form is discussed, as well as freeze-drying, tableting capsule filling, and form/fill/seal, and proper labeling of final drug forms.

PHEN 606. Pharmaceutical Unit Operations: Solids Processing. 3 credits, 3 contact hours.
This course examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving solids processing, such as solids characterization, blending, milling, granulation, tableting, coating, and others. The emphasis is primarily on the engineering aspects of the pharmaceutical processes examined in the course.

PHEN 612. Pharmaceutical Reaction Engineering. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603; undergraduate courses in differential equations and chemical engineering kinetics, or completion of bridge program for students who are required to take it. This course examines a variety of reactions and reactors typically encountered in the pharmaceutical industry, including single/multiphase systems (e.g., crystallization), chemical synthesis, enzymatic, bio-reactions (fermentation), and others. The course then focuses on quantitative pharmaceutical reactor design and scale-up issues.

PHEN 614. Pharmaceutical Separation Processes. 3 credits, 3 contact hours.
This course covers separation processes in general and pharmaceutical separations in particular. Specific processes to be studied include distillation, extraction, crystallization, adsorption, ion exchange, chromatography, moving bed processes, electrophoresis, freeze drying, microfiltration/ultrafiltration, reverse osmosis, and pervaporation.

PHEN 618. Principles of Pharmacokinetics and Drug Delivery. 3 credits, 3 contact hours.
The course covers the basic principles of pharmacokinetics, including drug transport, parenteral and enteral routes of drug administration, and factors affecting drug absorption, distribution, metabolism, and excretion. Mathematical pharmacokinetic models and drug delivery processes are also presented and quantitatively studied.

PHEN 698. Special Topics in Pharmaceutical Engineering I. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 699. Special Topics in Pharmaceutical Engineering II. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the Master's degree in pharmaceutical engineering. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the pharmaceutical engineering faculty, and one other faculty member. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHEN 701B. Master'S Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: PHEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in pharmaceutical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in PhEn 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHEN 701C. Master'S Thesis. 6 credits, 3 contact hours.
Corequisite for full-time students: PHEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in pharmaceutical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (PHEN 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHEN 702. Selected Topics in Pharmaceutical Engineering. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 725. Independent Study. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

PHEN 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for PHEN 726 if they have taken PHEN 725 in a prior semester. Students cannot register for this course with the same advisor as they had in PHEN 725.

PHEN 791. Graduate Seminar. 0 credits, 0 contact hours.
Required, when offered, of all pharmaceutical engineering graduate students receiving departmental or research-based awards. The student must register each semester until completion of the degree, if the Graduate Seminar is offered. Outside speakers and department members present their research for general discussion.

TRAN 552. Geometric Design of Transportation Facilities. 3 credits, 3 contact hours.
Prerequisite: CE 350 or equivalent. Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design, speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. Same as CE 552.

TRAN 553. Design and Construction of Asphalt Pavements. 3 credits, 3 contact hours.
Importance of designing asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. Same as CE 553.

TRAN 592. Graduate Co-op Work Experience. 1 credit, 1 contact hour.
Prerequisites: permission from Transportation Program and Division of Career Development Services. Work assignments and projects are developed by the co-op office in consultation with the transportation program. Work assignments are related to student's major and are evaluated by Transportation Program faculty coordinators. Credits for this course may not be used to fulfill any transportation degree requirements.

TRAN 602. Geographic Information Systems. 3 credits, 3 contact hours.
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces emerging technology and its applications. Same as CE 602.

TRAN 603. Introduction to Urban Transportation Planning. 3 credits, 3 contact hours.
Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined. Same as CE 603.

TRAN 608. Behavioral Issues in Transportation Studies. 3 credits, 3 contact hours.
Behavioral science concepts and principles such as perception, learning, motivation, and information processing as they relate to: transportation, consumer use of mass transit, automobiles, ridesharing and intelligent transportation systems. Same as HRM 608.

TRAN 610. Transportation Economics. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in economics. Principles of engineering economy. Cost of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. Same as IE 610.

TRAN 615. Traffic Studies and Capacity. 3 credits, 3 contact hours.
Prerequisite: elementary probability and statistics. Presentation of the characteristics of the traffic stream, road users, and of vehicles, and a review of traffic flow relationships. Students are exposed to the principal methodologies followed by transportation practices to perform volume, speed, travel time, delay, accident, parking, pedestrian, transit and goods movement studies. Presentation of the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections. Students get hands on experience using highway capacity software (HCS) and SIDRA. Same as CE 660.

TRAN 625. Public Transportation Operations and Technology. 3 credits, 3 contact hours.
Prerequisite: graduate standing in civil or industrial engineering or instructor approval. Presentation of the technological and engineering aspects of public transportation systems. Historical development of public transportation technologies. Vehicle and right-of-way characteristics, capacity and operating strategies. Public transportation system performance. Advanced public transportation systems. Same as CE 625.

TRAN 640. Distribution Logistics. 3 credits, 3 contact hours.
Prerequisite: EM 602 or TRAN 650 or equivalent. Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. Same as EM 640.

TRAN 643. Transportation Finance. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. Same as IE 643.

TRAN 650. Urban Systems Engineering. 3 credits, 3 contact hours.
Prerequisite: computer programming background. Identifies the various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods, mathematical modeling and simulation, and decision making under uncertainty. Same as CE 650.

TRAN 653. Traffic Safety. 3 credits, 3 contact hours.
Prerequisite: TRAN 615 or equivalent. System behavioral principles are applied to safety aspects of highway operation and design, and improvements of existing facilities. Solutions are evaluated on the basis of cost effectiveness. Same as CE 653.

TRAN 655. Land Use Planning. 3 credits, 3 contact hours.
Spatial relations of human behavior patterns to land use; methods of employment and population studies are evaluated; location and spatial requirements as related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. Same as CE 655 and MIP 655.

TRAN 659. Flexible and Rigid Pavements. 3 credits, 3 contact hours.
Prerequisite: CE 341 or equivalent. Types of rigid (Portland cement) and flexible (bituminous pavements). Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. Same as CE 659.

TRAN 700. Masters Project. 0 credits, 0 contact hours.
Prerequisite: written approval of project advisor. An independent project demonstrating the student's professional competence in an area of specialization. Oral examination and written report required.

TRAN 700B. Master'S Project. 3 credits, 3 contact hours.

TRAN 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: written approval of thesis advisor. A comprehensive project, usually in the form of substantial study and analysis, a functional design project or control-operations systems study.

TRAN 701B. Master'S Thesis. 3 credits, 3 contact hours.
Prerequisite: written approval of thesis advisor. A comprehensive project, usually in the form of substantial study and analysis, a functional design project or control-operations systems study.

TRAN 701C. Master'S Thesis. 6 credits, 3 contact hours.
Prerequisite: written approval of thesis advisor. A comprehensive project, usually in the form of substantial study and analysis, a functional design project or control-operations systems study.

TRAN 702. Topics In Transportation. 3 credits, 3 contact hours.
Prerequisite: advisor's approval. Topics of special or current interest.

TRAN 705. Mass Transportation Systems. 3 credits, 3 contact hours.
Prerequisite: TRAN 610 or IE 610. Investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. Same as CE 705.

TRAN 720. Discrete Choice Modeling for Travel Demand Forecasting. 3 credits, 3 contact hours.
Prerequisite: TRAN 610 or equivalent. Discrete choice modeling describes a class of theoretical and analytical models essential for most advanced planning and forecasting efforts in transportation analysis. Includes logit, multi-nominal, and probit models. Develops theoretical and analytical skills needed to design, estimate and apply both revealed and stated preference models to appropriate travel demand forecasting problems.

TRAN 725. Independent Study. 3 credits, 3 contact hours.

TRAN 726. Independent Study II. 3 credits, 3 contact hours.

TRAN 752. Traffic Control. 3 credits, 3 contact hours.
Traffic laws and ordinances; regulatory measures; traffic control devices; markings, signs and signals; timing of isolated signals; timing and coordination of arterial signal systems; operational controls; flow, speed, parking; principles of transportation system management/ administration; highway lighting; and state-of-the-art surveillance and detection devices and techniques. Hands-on experience with TRAF/NETSIM and FREESIM. Same as CE 752.

TRAN 753. Airport Design and Planning. 3 credits, 3 contact hours.
Prerequisites or corequisites: TRAN 610 or EM 693 and TRAN 615. Planning of individual airports and statewide airport systems. Functional design of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. Same as CE 753 and IE 753.

TRAN 754. Port Design and Planning. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or EM 693 and TRAN 615. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. Same as CE 754 and IE 754.

TRAN 755. Intelligent Transportation Systems. 3 credits, 3 contact hours.
Prerequisite: TRAN 752. Techniques used to improve the safety, efficiency and control of surface transportation systems. Emphasis on technological and operational issues of these systems and using them for incident detection and for traffic management through route and mode diversion.

TRAN 760. Urban Trans Networks. 3 credits, 3 contact hours.
Prerequisites: elementary probability and statistics and TRAN 650 or equivalent. Provides analytical techniques for the analysis of transportation problems in an urban environment. Principal components include applications of models for the analysis of transportation problems, advanced static, dynamic, and stochastic traffic assignment procedures and transportation network design exact and heuristic solution algorithms. Offers hands-on experience with existing software in traffic assignment and transportation network design.

TRAN 765. Multi-modal Freight Transportation Systems Analysis. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or equivalent and TRAN 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. Same as EM 765 and CE 765.

TRAN 790. Doctoral Dissertation. 0 credits, 0 contact hours.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester thereafter.

TRAN 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester.

TRAN 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester.

TRAN 790C. Doctoral Dissertation. 6 credits, 3 contact hours.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester.

TRAN 790D. Doctoral Dissertation. 9 credits, 3 contact hours.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester.

TRAN 790E. Doctoral Dissertation. 12 credits, 3 contact hours.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester.

TRAN 790F. Doctoral Dissertation. 15 credits, 3 contact hours.
Corequisite: TRAN 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester.

TRAN 791. Doctoral Seminar. 0 credits, 1 contact hour.
Corequisite: TRAN 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in transportation. Students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

TRAN 792. Pre-Doctoral Research. 0 credits, 0 contact hours.
Prerequisite: Permission of program director. For students admitted to the Doctor of Philosophy Program in Transportation who have not yet passed the qualifying examination. Research is carried out under the supervision of a faculty member in the program. Up to 6 credits may be applied toward the required dissertation credits for the program.

TRAN 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.

TRAN 792C. Pre-Doctoral Research. 6 credits, 3 contact hours.

Biomedical Engineering

Biomedical engineering is currently the fastest growing field of engineering in the U. S. and requires an education that draws from advanced engineering and computing as well as the biological and medical sciences. NJIT offers an extremely flexible Masters program that encourages students to contribute to an individualized plan of study that builds upon the strengths of their B.S. and develop expertise in an area of concentration leading to careers in research and/or product development, or to prepare for further study in medicine, dentistry, law, and management, or for a Ph.D. in biomedical engineering. Major areas in which NJIT offers courses and conducts research are bioinstrumentation, biomaterials and tissue engineering, biomechanics, neural engineering and rehabilitation engineering.

Over the past several years, the M.S. in Biomedical Engineering program at NJIT currently has graduated the largest number of M.S. degrees in BME in the nation. The department offers a comprehensive set of courses specifically in biomedical engineering (usually 14-16 per semester), which are augmented by related engineering and life science courses taught in other departments. NJIT's location, in the middle of the nation's largest concentration of biomedical industries, provides access to expert instructors who offer specialized courses, which add to the richness of the academic environment. These industries also support graduate internships and thesis work, and often provide employment after graduation. The NJIT campus is within walking distance of both the University of Medicine and Dentistry of New Jersey flagship campus and Rutgers University-Newark. Graduate education at the three institutions is enhanced by collaboration agreements that allow cross-registration for courses, use of libraries, and opportunities for independent research. This benefits biomedical engineering by opening the possibilities for M.S. students to take advanced biological and medical science courses in addition to engineering courses.

The NJIT Department of Biomedical Engineering has a very active research program that is accessible to Masters students and provides opportunities for thesis or other independent study, which integrates engineering and the medical sciences. Research is conducted cooperatively between NJIT and the medical and dental schools of RBHS, the Kessler Institute for Rehabilitation, St. Barnabas Medical Center, Veteran's Administration Medical Center in East Orange, the Children's Specialized Hospital, the Public Health Research Institute, the Rutgers Center for Biological and Molecular Neuroscience and other institutions in the New Jersey-New York metropolitan area. In addition, cooperative research opportunities exist with a number of biomedical device and pharmaceutical companies within a short commuting distance from NJIT.

The Doctor of Philosophy in Biomedical Engineering is jointly offered by NJIT and Rutgers Biomedical and Health Sciences (RBHS). It offers advanced graduate education providing students with the skills necessary for careers in basic and applied research, as well as the intellectual foundation to provide leadership in academia and industry. This program emphasizes an integration of engineering and the life sciences to address complex problems. Students are admitted to either institutions and receive the same degree with a joint diploma. Course requirements are the same regardless of admission. The RBHS description of this program can be found at http://njms.rutgers.edu/sgs/current_students/phd/bio_engineering/index.php (http://njms.rutgers.edu/sgs/current_students/phd/bio_engineering/)

The recent National Research Council Ph.D. rankings placed it 26th out of 74 U.S. BME Ph.D. programs.

Aim of the M.S. Program

This program provides the opportunity for individuals with degrees in biomedical engineering to focus on a specialized area to a much greater degree than could be done in their undergraduate studies. Similarly, it also allows those with engineering and science backgrounds in other fields to acquire knowledge and skill that will allow them to join this growing field. Unlike many other graduate programs, the NJIT BME M.S has no core requirements. Each student develops an individualized plan of study with his or her advisor that is based on prior study, past work experience and career goals. The intentional flexibility in the selection of courses reflects the expected maturity of the graduate students as they assume significant responsibility for planning their concentrations. This flexibility also encourages students to exhibit some curiosity about unfamiliar areas of biomedical engineering and allows them to take two courses that may be peripheral to their academic focus.

The opportunity to pursue a thesis has the benefit of allowing students to choose a topic in which they will demonstrate the ability to integrate what they have learned, execute a 2-semester technical project, and communicate their results. Students not electing to pursue a thesis may choose three additional courses (replacing the 6-credit thesis) that increase their depth in engineering and breadth in the life sciences.

Eligibility for the Program

Students who have a B. S. degree in science or engineering are eligible. In general, those with a B.S. in biomedical, mechanical, electrical, computer or chemical engineering will be well prepared to enter the program. Exceptional students with undergraduate degree in the life sciences with sufficient background in mathematics will also be considered for admission.

All applicants must have had courses in scientific computer programming, differential equations, statistics, and physiology. Students who are missing one or more of these can be conditionally admitted with a requirement to take undergraduate bridge courses, which are in addition to the 30-credit graduation requirement. Certain graduate courses or concentrations may require additional background, such as, statics and/or dynamics, thermodynamics, and electronics. Students who do not have these prerequisites may be asked to take additional courses or acquire the necessary material through tutoring and independent study. Prospective students may contact the M.S. Program Director for advice regarding their specific needs.

Students selected for admission should have earned a minimum undergraduate G.P.A. of 3.0, and have GRE Math and Verbal scores higher than 670 and 400, respectively. GRE scores are required for all international applicants, and are optional for graduates of U.S. universities and colleges.

Course Offerings

The courses offered through this program allow students to choose concentrations that genuinely reflect their needs and interests. The sample course concentrations listed below reflect a curriculum that is rich in cutting edge engineering and science, and deep in its content. This critical mass of courses at NJIT, RBHS and Rutgers allows students to acquire a level of expertise that is uncommon among most biomedical engineering programs. The students in this program are nearly evenly split between those continuing their education immediately following their B.S. and those who are returning to study after a number of years of employment. The same is true for the educational backgrounds of the students, with approximately half having studied biomedical engineering and the other half coming from different fields. Most candidates for the Masters degree enroll as full-time students. However, the degree can be completed on a part-time basis for those who wish to study while continuing to work. Most courses are offered in the late afternoon and in the evening.

The BME graduate courses listed in this catalog are each offered at least once per academic year. This listing is frequently updated to avoid the potential of including courses that are no longer offered. Potential applicants are encouraged to view the current academic year's course schedule and course enrollments at http://www.njit.edu/registrar/schedules/.

Course are taught by faculty who have considerable expertise. BME faculty and lecturers from nearby medical institutions offer graduate courses that are related to their ongoing research areas, while lecturers from industry bring experience from a corporate sector.

Approximately 30% of BME M.S. students complete a thesis, which is a mentored two-semester research/development experience. Many students (particularly those with experience in industry) may already have experienced the equivalent of an in-depth, year-long project, and can be better served by taking additional courses. Students considering a thesis are directed to the NJIT Library's website where most recent theses are available online. Those who have questions about the scope and content of biomedical engineering theses should review several that fall within their areas of interest. These can be found at http://archives.njit.edu/vhlib/etd/list-programs.php#Biomedical-Engineering.

The department's Graduate Seminar is a weekly opportunity for students to be exposed to current topics in biomedical engineering and develop an appreciation for the breadth of this exciting field. These lectures are given by visiting scholars and industry experts. The department website offers a current listing of seminar speakers and topics. Please visit http://biomedical.njit.edu/.

In addition to the department seminar, the Graduate Biomedical Engineering Society (GBMES) operates its own lecture series that focuses on BME in industry. Monthly speakers discuss product development and applied research. Many speakers are NJIT BME alumni with whom current students can network.

Co-op Opportunities and Internships

Students have the opportunity to participate in the co-op and internship programs at neighboring medical institutions or at biomedical engineering firms to gain practical experience. NJIT is situated in an area that contains many major biomedical engineering and pharmaceutical companies. The biomedical engineering department has a part-time advisor for co-op and internship experiences.

Prospects for Employment

Considerable opportunity exists in the field of biomedical engineering. This takes the form of basic and applied research and product development. Employment may be found in medical institutes, government agencies, corporations and hospitals, all of which are involved in the design, manufacture and utilization of equipment and procedures intimately involved in health care improvement. Many students go on to obtain professional degrees in medicine, dentistry, law or administration for which an engineering background is becoming ever more important.

Admission Requirements

Prospective students seeking admission to the Program must have an undergraduate degree in engineering, science or mathematics and satisfy the admission and academic requirements of the Graduate School.

1. General Guidelines. Each program of study must satisfy the Graduate School academic requirements (see the latest graduate catalog at www.njit.edu (http://www.njit.edu)).
2. Prerequisite Courses. Minimum Undergraduate Requirements for the Program:
   - B.S. in Biomedical, Chemical, Electrical, Computer, or Mechanical Engineering.
   - Applicants with a B.S. in Computer Science are expected to have had Calculus through differential equations, one full year of Physics, one full year of Chemistry, and a course in Physiology.
   - Applicants with strong life science or medical education, including the equivalent of one full year of Physics as well as Calculus through differential equations, will be considered on a case-by-case basis.
   - Conditional admission may be granted to applicants lacking full preparation with a requirement to take undergraduate bridge courses that will not carry graduate credit.

Admitted students who have not previously taken an upper level physiology course will be required to take BME 669 Engineering Physiology or an equivalent course as one of their graduate courses.

Applicants with a background in life science or other related degrees, such as biology, biochemistry, physical therapists, etc. may be conditionally admitted to the program. Admitted students will be required to register for bridge courses in their first semester prior to taking graduate level BME courses as a condition of admission. In general, the following courses will be required, pending review of transcripts by the graduate advisor:

Calculus 1,2, and 3
Differential Equations
Introduction to Computer Programming
BME 301 Electrical Fundamentals of Biomedical Engineering or equivalent
BME 302 Mechanical Fundamentals of Biomedical Engineering or equivalent

Students must complete BME 301 and BME 302 with a minimum grade of B. Failure to receive a B grade in bridge courses may preclude students from enrolling in regular graduate BME courses. Equivalent courses may be accepted with prior approval from graduate advisor.

Aims of the Ph.D. Program

This joint program builds upon the synergistic relationship between NJIT and RBHS. The physical proximity of the two institutions facilities access to courses, laboratories, libraries, and seminars, as well as blending scientific and clinical opportunities in education and research. In addition, the location of NJIT and RBHS in Newark promotes interaction with New Jersey's pharmaceutical and medical device industries and medical facilities. As the preparation for the Ph.D. involves an extensive research apprenticeship in the form of dissertation, the program is closely linked to the areas of biomedical engineering research at NJIT and RBHS. This research is clustered in the following areas.

- Biomaterials and Biocompatibility
- Tissue Engineering and Regenerative Medicine
- Cellular and Orthopedic Biomechanics
- Biomedical Signal Processing, Imaging and Instrumentation
- Neural and Neuromuscular Engineering

The program requires a minimum of 78 credits beyond the B.S. or 60 credits beyond an M.S. degree in biomedical engineering or closely related field. For the post M.S. student, 24 credits must be in advanced graduate level courses with 12 credits in biomedical engineering and 12 credits in life sciences. The post B.S. student must take an additional 18 credits in approved courses.

The remaining 36 credits are comprised of mentored dissertation research, in which the student demonstrate aptitude for independent research of publishable nature. Individuals completing this degree are well-prepared for employment in academia, industry and government laboratories, or for post-doctoral study.

Eligibility for the Program

Prospective students seeking admission to the joint Ph.D. Program should have an undergraduate degree in engineering, basic science or mathematics, and satisfy the admission and academic requirements of the NJIT Graduate School and the RBHS Graduate School of Biomedical Sciences. In general, applicants are expected to have had Calculus through differential equations equations, one full year of physics, one full year of chemistry, and a course in physiology as part of their prior engineering studies. Non-engineering applicants with strong life science or medical education, with the same physics, chemistry, math and physiology background, but who do not have experience in essential engineering sciences, will be considered on a case-by-case basis. These applicants may be asked to pursue and M.S. in BME prior to admission to the Ph.D. program. Alternatively, conditional admission may be granted to applicants lacking full preparation, the a requirement to take undergraduate bridge courses that will not carry graduate credit. Admitted students who have not previously taken an upper level physiology course will be required to take BME 669 Engineering Physiology or an equivalent course as one of their graduate courses.

Applicants are expect to have a minimum G.P.A of 3.5 in their most recent degree (B.S. or M.S.) and minimum GRE Math and Verbal scores of 750 and 500. The GRE is required for all applicants, and TOEFL is required for all international students.

The program has a joint admission committee, which reviews all application, thus allowing students to apply to either institution. The host institution for a student may be changed depending upon the eventual research advisor and/or the institutional source of the research funding. The only significant institutional difference in the application process is that RBHS only admits students in the spring for the upcoming fall semester. NJIT can admit students who are beginning in either the fall or spring semesters. In general, however, spring admissions are rare.

As the Ph.D. program is significantly based on faculty research, admission depends upon available opportunities and funding in individual laboratories, in addition to prior academic performance. A very limited number of teaching assistantships and university fellowships are available for begging students, with subsequent years of research supported by faculty grants.

Laboratory and funding opportunities vary considerably from year to year. Serious potential applicants are encouraged to contact the Ph.D. program director at either NJIT or RBHS to discuss the current factors influencing admission.

NJIT Faculty

A

Adamovich, Sergei, Associate Professor

Alvarez, Tara L., Professor

Arinzeh, Treena L., Professor

B

Biswal, Bharat, Professor

C

Chandra, Namas, Professor

Chaudhry, Hans, Research Professor

Cho, Cheul, Assistant Research Professor

D

Di, Xin, Assistant Research Professor

F

Foulds, Richard A., Associate Professor

G

Georges Deveau, Penelope, University Lecturer

H

Haorah, James, Associate Professor

Hunter, William C., Professor

I

Ihlefeld, Antje, Assistant Professor

J

Jaffe, Michael, Research Professor

L

Lee, Eun Jung, Assistant Professor

Li, Xiaobo, Associate Professor

M

Mantilla, Bruno Antonio, University Lecturer

O

Ophir, Zohar, Research Professor

P

Perez-Castillejos, Raquel, Assistant Professor

Peringady, M. A. Muneer, Assistant Research Professor

Pfister, Bryan J., Chair

R

Reisman, Stanley, Professor Emeritus

S

Sahin, Mesut, Professor

Schesser, Joel, Senior University Lecturer

Skotak, Maciej, Assistant Research Professor

V

Van Buskirk, William C., Distinguished Professor Emeritus

- Biomedical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/ms/)
- Biomedical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/phd/)

Programs

- Biomedical Device Development (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/cert/)

Biomedical Engineering Courses

BME 590. Graduate Co-Op Work Exper I. 1 credit, 1 contact hour.

BME 591. Graduate Co-Op Work Exper II. 1 credit, 1 contact hour.

BME 592. Graduate Co-Op Work Exper III. 1 credit, 1 contact hour.

BME 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

BME 601. Seminar. 1 credit, 1 contact hour.
Required every semester of all master's students in biomedical engineering who receive departmental or research-based support and all doctoral students. To receive a satisfactory grade, students must attend at least five seminars per semester, as approved by the seminar supervisor.

BME 611. Engineering Aspect of Molecular and Cellular Bio I. 1 credit, 1 contact hour.
Molecular and cellular biology is a foundation of the understanding of the biological sciences and is vital to the study of advanced biomedical engineering. This course is to be taken simultaneously with UMDNJ N551 to enrich the crossover between engieering and life sciences. Course topics parallel those covered in N551 and both add engineering relevance, and provide engineering students with a stronger understanding of molecular and cellular biology. For students in joint BME PhD program.

BME 612. Engineering Aspects of Molecular and Cellular Bio 2. 1 credit, 1 contact hour.
Molecular and cellular biology is a foundation of the understanding of the biological sciences and is vital to the study of advanced biomedical engineering. This course is to be taken simultaneously with UMDNJ N552 to enrich the crossover between engineering and life sciences. Course topics parallel those covered in N552 and both add engineering relevance, and provide engineering students with a stronger understanding of molecular and cellular biology. For students in joint BME PhD program.

BME 650. Clinical Physiology & Neurophy. 3 credits, 3 contact hours.
Prerequisites: BME 111, BME 303, BME 382 or permission of the instructor. Topics to be covered include gastrointestinal tract, pulmonary respiratory system, renal and liver functions, blood and hemodynamic, cardiovascular and cerebrovascular function, and understanding of neurophysiology in human neurological diseases.

BME 651. Principles of Tissue Engineering. 3 credits, 3 contact hours.
Tissue Engineering is a therapeutic approach to treating damaged or diseased tissues in the biotechnology industry. In essence, new and functional living tissue can be fabricated using living cells combined with a scaffolding material to guide tissue development. Such scaffolds can be synthetic, natural, or a combination of both. This course will cover the advances in the fields of cell biology, molecular biology, and materials science towards developing novel "tissue engineered" materials.

BME 652. Cellular and Molecular Tissue Engineering. 3 credits, 3 contact hours.
This course explores molecular, cellular and tissue level interactions that are an important component of all tissue engineering strategies. Topics include how a cell moves, reacts and maintains viability and function based on its surroundings. We will discuss how to engineer our materials, tissue grafts and implants to integrate with the body. We will also liearn about bodily reactions and the biocompatibility of tissue engineered devices such as immunoreactivity and blood coagulation.

BME 653. Micro/Nanotechnologies for Interfacing Live Cells. 3 credits, 3 contact hours.
In this course, we will study technologies and tools available for interfacing live cells from a sub-cellular, single-cell, and multi-cellular (tissue models) approach. We will introduce key concepts of the biology of cells and tissues and will explore the technologies (micro-/nanotechnologies) and tools (sensors and actuators) available for the investigation of cell and tissue biology. Same as ECE 653.

BME 654. Cardiovascular Mechanic. 3 credits, 3 contact hours.
Fundamental biomechanical mechanisms at work in the cardiovascular system. Topics include the fundamental molecular structure of heart muscle, the biomechanical principles that transform the contraction of heart muscle into stress-strain functions of muscle fibers, pressure-volume flow relations in the vasculature when it is considered as a hemodynamic (blood hydraulic) system, growth and disease of the cardiovascular system, resistance, compliance, inertance, and catheter-tip transducers.

BME 655. Advanced Characterization of Biomaterials. 3 credits, 3 contact hours.
Prerequisites: MTSE 301 or undergraduate equivalent, BIOL 201 or undergraduate equivalent, one semester of undergraduate organic chemistry. With a focus on contemporary biomaterials in the published literature and clinical practice, biomaterial chemical and mechanical testing will complement synthesis theory. Communication and articulation of ideas will be honed in the form of literature debates, write-ups, demonstration/performance of analytical techniques, and concluding with translation of biomaterials that will include entrepreneurship and regulatory aspects.

BME 656. Research Skills in Stem Cell. 3 credits, 3 contact hours.
Stem cells have emerged as new therapeutic potential and offer great opportunities for regenerative medicine, biotechnology and the pharmaceutical industry. This course is intended for graduate students interested in stem cell bioengineering and tissue engineering. The course will cover stem cell biology and biomedical engineering applications for cell-based regeneration therapies. It will discuss techniques for engineering of stem cells and the current literature in this rapidly evolving field.

BME 661. Neural Engineering. 3 credits, 3 contact hours.
Neural Engineering focuses on understanding how the brain functions using engineering principles. The course discusses different instrumentation and signal processing algorithms to study how the brain functions, how to detect different pathologies and new applications for research. Topics include; basic overview of neurology, vector populations, neural networks, vision research, functional MRI, functional electrical stimulation, neural prosthetics, and other advanced research topics studying neurology.

BME 667. Bio-Control Systems. 3 credits, 3 contact hours.
The course provides an introduction to dynamic and control in biological systems, with particular emphasis on engineering aspects of biological oscillators/waves which govern the basic operations of all living organisms and especially higher order life forms. A combination of theoretical and simulation tools will be applied to analyze the qualitative and quantitative properties of selected biological systems. Feedback and control mechanisms in selected biological systems will be introduced. Same as ECE 667.

BME 668. Medical Imaging Systems. 3 credits, 3 contact hours.
This course provides a detailed introduction to medical imaging physics, instrumentation, data acquisition and image processing systems for reconstruction of multi-dimensional anatomical and functional medical images. Three-Dimensional medical imaging modalities including X-ray, Computer Tomography, Magnetic Resonance Imaging, Single Photon Emission Computer Tomography, Positron Emission Tomography, Ultrasound and optical imaging modalities are included. Same as ECE 668.

BME 669. Engineering Physiology. 3 credits, 3 contact hours.
To enable students to apply basic tools in engineering analysis, mathematics, computer science, general physics and chemistry courses so that they can develop models that quantitatively predict the functioning of physiological systems in the human body. To enable students to apply engineering systems analysis to systematic physiology and employ the ideas of feedback control, signal procession, mathematical modeling and numerical simulation. Same as ECE 669.

BME 670. Introduction to Biomechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment. Same as ME 670.

BME 671. Biomechanics of Human Structure and Motion. 3 credits, 0 contact hours.
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

BME 672. Biomaterials. 3 credits, 3 contact hours.
Prerequisite: MECH 320 (see undergraduate catalog for description) or the equivalent. Materials and processes used to develop devices that are implanted in the human body; clinical aspects of biomechanical engineering; federal government requirements for design and testing of human implant devices; biocompatibility, metal implant devices, material design parameters, plastic and ceramic devices, sterilization techniques, and their effect on biocompatibility.

BME 673. Biorobotics. 3 credits, 3 contact hours.
Basics of control of a robot and telemanipulation are studied. Computer simulations, MATLAB are used to explore biomimetic autonomous robots. This is a studio-based course with hands-on exercises with small robots and actuators. Topics include understanding how biological robots (humans and animals) differ from designed robots, as well as sensors (touch, stereo and position), actuators (muscles, smart materials), and intelligent (neural and computer controlled systems.

BME 674. Principles of Neuromuscular Engineering. 3 credits, 3 contact hours.
Neurophysiology, motor control and robotics are used to study the human motor system. Sensorimotor learning and acquisition of new motor skills are emphasized. Topics include the central nervous system, muscle properties, spinal motor circuitry and dynamics of limb motion. The relation of motor control problems to neurophysiology of the motor system and how motor disorders affect movement control are studied. MATLAB and Simulink are used in simulations and movement date analysis.

BME 675. Computer Methods in Biomedical Engineering. 3 credits, 3 contact hours.
This course uses MATLAB to concentrate on methods that allow students to produce original software that can be used to acquire, process, analyze and present data. Topics include advanced graphics and animation, graphical user interfaces, interfacing to and data acquisition from laboratory instrumentation, filtering and processing of acquired data, and interfacing to user interfaces (e.g. joysticks). Applications in speech, bioelectrical signals, images and virtual reality will be included.

BME 676. Computational Biomechanics. 3 credits, 3 contact hours.
Prerequisites: BME 670 or equivalent. The use of commercially available software to solve complex engineering problems has become standard practice to reduce time and cost and results in a better product. This is an intro course on computational methods and the use of commercial software such as ANSYS, Fluent, and MATLAB to solve problems related to the BME device industry. Suitable for students interested in Computer Aided Design and Engineering (CAD/CAE).

BME 677. CAD for Biomechanics and Biomaterials. 3 credits, 3 contact hours.
Introduction to Computer Aided Design theory and application using software. Topics include datum planes, extrude, cut, sweep, swept cuts, and parallel, rotational, and general blends. Assemblies and generating, dimensioning, editing, and modifying drawing views and creation of balloons, imaging and scanning techniques of anatomical structures such as bone and arteries and 3D printing are also covered.

BME 678. Design of Orthopedic Implants. 3 credits, 3 contact hours.
Prerequisite: BME 677. First of a two part course on design of orthopedic implants using ProEngineer. Additional topics include machanical properties of implant materials, material selection and introduction to FEA. Methods for prototype development with the use of 3D printing will also be discussed. A critical objective of this course is the preparetion of design reports and project presentations.

BME 679. Advanced Design of Orthopedic Implants. 3 credits, 3 contact hours.
Prerequisites: BME 677, BME 678 or equivalent. Advanced modeling techniques for the design of hip, knee, and spine implants. Mechanical properties of materials, including wear and failure modes associated with typical implants. Kinematics and surgical protocols of implants will be discussed. Course will cover assemblies and FEA analysis of implants. Additional topics include large deformations, fatigue, optimization, review and analysis of results.

BME 680. BioMEMS Design and Applications. 3 credits, 3 contact hours.
The advance of bioMEMS (Micro Electrical Mechanical Systems) technology is a key component in making the next generation medical diagnostic tools possible. We will learn how bioMEMS devices are fabricated and combine engineering analysis with knowledge of known biological responses and biomolecule interactions to understand how bioMEMS are designed and function. Topics will include biological, mechanical, electrical, and chemical biosensors, and microfluidics as applied to biotechnology.

BME 682. System Mgmt for Medical Device. 3 credits, 3 contact hours.
This course will provide a detailed overview of Project Management techniques and methods applied to medical devices and show the integration of medical device Design Controls from 21 CFR820.30. General knowledge from the field of Project Management will be conveyed from the perspective of engineering or science personnel in the industrial medical field, particularlywith regard to FDA Quality System Regulations (QSR), ISO 13485 guidelines, and Good Clinical Practices (GCP's) for running clinical trials. Students will also take part in practical problem solving simulations based on real-world examples of medical device project anomalies. The combination of specialized project management knowledge for a heavily regulated area and realistic classroom simulation will provide a basis for those interested in commercial medical device development.

BME 684. Medical Device Development. 3 credits, 3 contact hours.
This course will provide a detailed overview of medical device development from a realistic industrial and academic perspective. The processes used in corporations and academic laboratories to conceive and develop devices will be explored from a research, regulatory, clinical, QA/QC, marketing, engineering, and legal perpective under the umbrella of project management techniques. Material will be presented as an aide to students who wish to decide on careers in either industry or academia.

BME 686. Intro. to Instrumentation for Physiomeasurements. 3 credits, 3 contact hours.
Introduction to instrumentation for students without instrumentation background only. This course teaches the hardware and instrumentation needed to measure variables from different physiological systems. Electrodes, sensors and transducers, bioelectric amplifiers safety and digital acquisition will be discussed. Hardware for measurement of the ECG, EEG, EMG, respiratory system, nervous system, clinical laboratory instruments, electrical safety and computers in biomedical instrumentation.

BME 687. Design of Medical Instrumentation. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electronics. Principles and practice of medical instrumentation. Instrument components and medical instrument systems design. Examples taken from electrocardiography, clinical chemistry, medical imaging. Microprocessor-based systems emphasized.

BME 688. Virtual Biomedical Instrument. 3 credits, 3 contact hours.
Introductory course to the programming language, LabVIEWTM. Topics include loops, arrays, clusters, data acquisition, and file input/output. Students will learn how to apply these basic concepts into the development of algorithms. Examples relevant to the biomedical industry will be given how to debug and solve complex programming problems. By the completion of the course, students will be able to develop programs to automate processes and experimental designs.

BME 698. Selected Topics. 3 credits, 3 contact hours.
Selected topics for Biomedical Engineering.

BME 700. Master's Project. 0 credits, 0 contact hours.
Prerequisite: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 700B. Master's Project. 3 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 701. Master's Thesis. 6 credits, 0 contact hours.
Prerequisite: written permission from thesis advisor. Projects include design, construction, experimental or theoretical investigation of the engineering applications to the diagnosis and/or treatment of disease. Research may be in cooperation with industry or medical institutions. Completed work should be of sufficient quality to be acceptable for publication. Oral presentations are required.

BME 701B. Master's Thesis. 3 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 701C. Master's Thesis. 6 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 725. Independent Study I. 3 credits, 3 contact hours.
Restriction: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count BME 725 as degree credit but can count these credits to qualify for full-time status.

BME 726. Independent Study II. 3 credits, 3 contact hours.
Restriction: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count BME 725 as degree credit but can count these credits to qualify for full-time status. This course is not available to master's students.

BME 741. Basic Plasma Physics with Spac. 3 credits, 3 contact hours.
Prerequisites: Phys 611, 621 or other equivalent, or approval of the instructor. The course will introduce students to basic concepts of plasma physics and its applications to laboratory experiments and space research. The course will cover the following topics: particle motions in magnetic field, adiabatic invariants, magnetic traps, radiation belts, electromagnetic waves in plasma, electrostatic oscillations, waves in magnetized plasma, collisional processes in plasma, kinetic effects on plasma waves, Landau damping, wave instabilities, plasma as fluid, magnetohydrodynamics, magnetic configurations of laboratory and space plasma, MHD instabilities, reconnection, helicity, dynamo theories, the origin of cosmic magnetic fields, stochastic processes, Fermi process, particle acceleration, and cosmic rays.

BME 760. Modeling in Func Brain Imaging. 3 credits, 3 contact hours.
Prerequisites: Although no prerequisites are required, BME 310, ECE 640 or other undergraduate and graduate courses covering knowledge on signals and systems in discrete time domain are suggested to prepare for this course. This course will focus on introducing biomedical computing techniques needed for functional MRI data pre-processing, and individual-level and group-level analyses. Several projects will be assigned for hands-on training in implementing the introduced knowledge.

BME 772. Adv Biomats for Lab and Clinic. 3 credits, 3 contact hours.
Prerequisite: BME 672 or equivalent. Background in Materials Science is encouraged. Advanced course on the design, characterization and clinical/research performance of biomaterials that have or may receive acceptance in medicine or as a biomedical research tool. The course requires the student to integrate background in chemistry, physics, cell and molecular biology, tissue engineering and materials science to review and summarize the scientific rationale for materials that have gained acceptance as medical devices, cell culture or diagnostic tools.

BME 774. Principles of Neurorehabilitation. 3 credits, 3 contact hours.
This is a research-focused course providing in-depth review of current studies in the following fields: Pathophysiology of disability; Advanced therapeutic interventions; Emerging neurorehabilitation technologies that are intended to encourage neural reorganization and relearning; Novel interfaces through chronic implementation in the brain, spinal cord and muscles used in deep brain stimulation, brain-machine interfaces, and functional electrical stimulation and Methods of assessing outcomes.

BME 788. Selected Topics. 3 credits, 3 contact hours.
Selected topics for Biomedical Engineering.

BME 790. Doctoral Dissertation. 0 credits, 0 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790B. Doctoral Dissertation. 3 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790C. Doctoral Dissertation. 6 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790D. Doctoral Dissertation. 9 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790E. Doctoral Dissertation. 12 credits, 12 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 790F. Doct Dissertation & Research. 15 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 791. Graduate Seminar. 0 credits, 0 contact hours.

BME 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Restriction: Permission of the department. For students admitted to the program leading to the Ph.D. in Computer Engineering or Electrical Engineering. Research carried on under the supervision of a designated member of the department faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under BME 790 after the student fulfills requirements of doctoral candidacy.

Biomedical Device Development

The objective of the graduate certificate in Biomedical Device Development is to address the clinical evaluation, regulatory, and commercial aspects of medical device development. It has been widely recognized by our industrial advisors, recent graduates, and industry adjuncts that having knowledge in this area is paramount to building a successful career as a biomedical engineer. The department of biomedical engineering currently offers several online-hybrid courses that address this need as part of our MS program in Biomedical Engineering. Enrollment in these courses and feedback by students has been overwhelmingly positive.

Who would be suited to take this program?

Working professionals in the biomedical engineering and related industries in the New Jersey area. Areas include manufacturing, universities, hospitals, research facilities of companies and educational and medical institutions, and government regulatory agencies.

What are the Required Courses?

Code	Title	Credits
Core Courses		
BME 682	System Mgmt for Medical Device	3
BME 684	Medical Device Development	3
BME 698	Selected Topics	3
BME 698	Selected Topics	3

What will I learn?

- *Systems Management for Medical Devices* - A detailed overview of Project Management techniques and methods applied to medical devices and the integration of medical device Design Controls from 21 CFR820.30. General knowledge from the field of Project Management will be conveyed from the perspective of engineering or science personnel in the industrial medical field, particularly with regard to FDA Quality System Regulations (QSR), ISO 13485 guidelines, and Good Clinical Practices (GCP's) for running clinical trials. Students will also take part in practical problem solving simulations based on real-world examples of medical device project anomalies. The combination of specialized project management knowledge for a heavily regulated area and realistic classroom simulation will provide a basis for those interested in commercial medical device development.
- *Medical Device Development* - A detailed overview of medical device development from a realistic industrial and academic perspective. The processes used in corporations and academic laboratories to conceive and develop devices will be explored from a research, regulatory, clinical, QA/QC, marketing, engineering, and legal perspective under the umbrella of project management techniques. Material will be presented as an aide to students who wish to decide on careers in either industry or academia.
- *Advanced Medical Device Development* - Exploring the primary events that occur from just before "design freeze" of a medical device up through clinical evaluation and commercial launch. Significant emphasis is placed on Quality Systems and Manufacturing, with attention to regulatory and legal compliance as well as design concepts.
- *Orthopedic Medical Devices* - A detailed discussion of biomaterials, biomechanics and medical devices in the Orthopedic therapeutic area. Medical devices discussed include soft and hard tissue fixation and repair devices, tissue engineered constructs and orthobiologics. Current industry and market trends in these areas will be explored and discussed. The regulatory landscape of medical device design and approval will be covered.

Why study Biomedical Device Development at NJIT?

The biomedical device industry is currently on the precipice of becoming more independently operated and developed by smaller entities going forward. There are expectations of industry mergers and acquisitions (http://www.meddeviceonline.com/doc/healthcare-trends-that-will-transform-medtech-in-0001/) headed into the near future as the industry fully develops. The current job titles most interested in this field would be:

- Quality Process Engineer
- Systems Engineer
- Production Engineer
- Staff engineer, Manufacturing
- Product Manager
- Project Engineer
- R&D Project Engineer
- Verification Engineer
- Medical Device Engineer
- Medical Device Reporting Supervisor
- Medical Device Sales
- Medical Device Validation Engineer

- Compliance Engineer
- Hardware-Electronics Engineer, Medical Devices

In addition, holders of this graduate certificate may find employment in the following industries: Health Care, Health Sciences, Bio-Medical Engineering, medical device industry, pharmaceutical industry, and other life science related industries

Prerequisites

An undergraduate degree in engineering, with an undergraduate cumulative grade point average (GPA) of at least 3.0 on a 4.0 scale is required. Applicants with a science degree and relevant industrial experience may be considered for conditional admission. Applicants with a GPA below 3.0 but at least 2.8, may also be conditionally admitted to the program. Conditions may involve completion of a bridge program designed on a case-by-case basis.

Related Degree Programs

The certificate program in Biomedical Device Development can convert to an MS in Biomedical Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/biomedical/ms/). Students who have completed an undergraduate degree in biomedical engineering may apply all certificate courses with a minimum final grade of B to the MS in BME. All other students may apply up to 2 certificate courses to the MS in BME.

Faculty Advisor: Max Roman (http://directory.njit.edu/PersDetails.aspx?persid=mxr6074)

M.S. in Biomedical Engineering

Program Requirements

Thesis Option

Code	Title	Credits
Five courses selected from list of BME mandatory courses (see below for complete list)		15
One graduate course in physiology or equivalent		3
One graduate course in experimental design, statistics, or clinical studies		3
BME 701 Master's Thesis		6
Any approved elective		3
BME 791	Graduate Seminar (required for two semesters)	0
Total Credits		30

Non-Thesis Option

Code	Title	Credits
Five courses selected from list of BME mandatory courses (see below for complete list)		15
One graduate course in physiology or equivalent		3
One graduate course in experimental design, statistics or clinical studies		3
Three approved electives		9
BME 791	Graduate Seminar (required for two semesters)	0
Total Credits		30

MS Curriculum Mandatory Courses

1. Admitted students who have not previously taken an upper level physiology course will be required to take BME 669 Engineering Physiology or an equivalent course as one of their required graduate courses.

2. In addition, students must meet a statistics requirement. They may choose one course from the following preapproved statistics courses: MATH 660 Introduction to statistical Computing with SAS and R, MATH 661 Applied Statistics, MATH 663 Introduction to Biostatistics, IE 604 Advanced Engineering Statistics.

All graduate students must additionally **select five** courses from the following list:

Code	Title	Credits
BME 651	Principles of Tissue Engineering	3
BME 652	Cellular and Molecular Tissue Engineering	3
BME 653	Micro/Nanotechnologies for Interfacing Live Cells	3
BME 654	Cardiovascular Mechanic	3

BME 661	Neural Engineering	3
BME 668	Medical Imaging Systems	3
BME 670	Introduction to Biomechanical Engineering	3
BME 671	Biomechanics of Human Structure and Motion	3
BME 672	Biomaterials	3
BME 673	Biorobotics	3
BME 674	Principles of Neuromuscular Engineering	3
BME 675	Computer Methods in Biomedical Engineering	3
BME 676	Computational Biomechanics	3
BME 678	Design of Orthopedic Implants	3
BME 679	Advanced Design of Orthopedic Implants	3
BME 680	BioMEMS Design and Applications	3
BME 687	Design of Medical Instrumentation	3
BME 688	Virtual Biomedical Instrument	3

Elective Courses

The remaining three courses can be selected from any of the BME courses offered. For students taking the MS Thesis Option, two semesters of thesis count as two elective courses.

Other Notes

Students may take up to two courses outside the department, including the statistics course.

Seminars

M.S. students are required to register for the 0 credit graduate seminar in each of a minimum of two semesters. This is a non-additive credit (i. e. it does not count toward the 30 required credits), however participation in the seminar is required for graduation. Graduate seminars are offered weekly during the semesters and include guest speakers as well as NJIT graduate students. The Department also maintains lists of seminars in other departments and in neighboring institutions that are of interest to biomedical engineering. Part-time graduate students may request a waiver of this requirement.

Thesis Requirement

The Thesis Option **requires** a six (6) credit thesis. Because biomedical engineering exists at the intersection of several traditional engineering and computing fields, and the biological and medical sciences, the thesis demonstrates the student's ability to define a problem, plan two semesters of independent work in an interdisciplinary environment, and execute a research and/or design that meets NJIT's standards for a Masters Thesis. The thesis document conforms to the format of the Office of Graduate Studies and is evaluated by a committee of three members, two of whom must be from the NJIT biomedical faculty. External members from industry, medicine or other universities are encouraged. An oral defense before the committee and the departmental community is also required. All NJIT theses are archived in the University Library and are available via the Library's web site.

Thesis topics are selected by the student in consultation with faculty and other potential advisors. Thesis content can include a research study, the development/design of new technology including software, or the design, execution and evaluation of an experiment. A thesis may be conducted in an NJIT laboratory or in another institutional or industrial facility. The individual nature of the work must be clearly identifiable, as should its novelty and importance to biomedical engineering.

In cases where the intellectual property of an industrial sponsor may be in conflict with the public presentation of the thesis or its availability through the NJIT Library, special arrangements can be made by the M.S. Program Director to protect the firm's property.

Ph.D. in Biomedical Engineering

The curriculum for this program is currently under review and will be updated shortly. In the meantime please contact with your advisor.

Chemical and Materials Engineering

The graduate programs in Chemical Engineering offer opportunities for students to enhance their knowledge in the core areas of the discipline, learn about advanced topics in various established as well as emerging technologies through specialized courses, and engage in original research. Courses are taught by full-time faculty members that are also involved in cutting-edge research, and adjunct faculty with extensive industrial experience.
The department enjoys close ties to the pharmaceutical and petrochemical industries, and plastics manufacturers through the Polymer Processing Institute (PPI). In addition to independent research, faculty members are associated with various research centers including the Center for Membrane Technology, the Particle Technology Center, and PPI. There are opportunities for interdisciplinary collaborative research with the Federated Department

of Biological Sciences, the Department of Biomedical Engineering, the Department of Chemistry and Environmental Science, and the University of Medicine and Dentistry of New Jersey.

Master of Science in Chemical Engineering

This program is intended for those interested in advancing their understanding of chemical engineering. It may be taken on a part-time or full-time basis. There are two options, one of which includes a master's thesis.

Admission Requirements

An undergraduate degree in chemical engineering is usually required. Students who do not have a degree in chemical engineering may be considered for admission through the bridge program. The bridge program is comprised of a sequence of three 3- credit courses PHEN 500, PHEN 501 and PHEN 502) specifically designed to provide non- chemical engineers with the necessary prerequisites to enter the program. The bridge courses cover a variety of topics, such as differential equations (especially applied to transport phenomena), optimization and business math (PHEN 500), mass balances, thermodynamics, and chemical kinetics (PHEN 501), and fluid flow, heat transfer and mass transfer (PHEN 502) Bridge courses are not counted toward degree credit.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. All full-time applicants pursuing a degree in the Otto H. York Department of Chemical and Materials Engineering also require a GRE. International students must achieve a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Chemical Engineering

This is a research-oriented degree intended primarily for full-time students. Although courses may be taken on a part-time basis, a minimum of one year of full-time residency is typically required for completion of the doctoral dissertation.

Admission Requirements

A master's degree in chemical engineering and a GPA of at least 3.5 on a 4.0 scale, or equivalent, are usually required. All applicants must submit GRE scores. International students must also achieve a minimum TOEFL score of 213 (computer-based) or 550 (non-computer-based). Exceptional students with undergraduate degrees in chemical engineering may also apply directly for admission to the doctoral program. In addition to the GRE and TOEFL requirements mentioned above, a minimum undergraduate GPA of 3.5 on a 4.0 scale, or equivalent, is normally required. Students admitted to the program without a master's degree in chemical engineering must complete an additional 18 credits of course work as specified below. Admission of full-time doctoral students is on a competitive basis as the department admits only as many students as it can support through departmental and research-based funds.

Pharmaceutical Engineering Program Objective

The Master of Science Program in Pharmaceutical Engineering is a program developed and administered by the Otto H. York Department of Chemical and Materials Engineering at NJIT. The primary objective of the program is to educate professionals and provide them with the skills required to work in the pharmaceutical field, with particular emphasis on the engineering aspects of drug manufacturing, pharmaceutical production, pharmaceutical development, and pharmaceutical operations.

The pharmaceutical/medical technology industry is the largest manufacturing industry in New Jersey. New Jersey is home to the headquarters of more global pharmaceutical and medical technology companies than any other state in the country, or any single country throughout the world. NJIT's M.S. program in Pharmaceutical Engineering provides the intellectual climate and the necessary tools needed to prepare students for positions and career advancement within the industry, based on the rigorous technological requirements of this highly regulated work environment.

The program is designed to provide opportunities for specialization in such areas as pharmaceutical processing and manufacturing, validation and regulatory issues in the pharmaceutical industry, pharmaceutical facility design, pharmaceutical packaging technology, reaction engineering for pharmaceutical production, pharmaceutical separation processes, pharmacokinetics and drug delivery, molecular modeling for drug discovery, pharmaceutical synthesis, fluid mixing in the pharmaceutical industry, instrumental analysis, and industrial quality control.

Master of Science in Pharmaceutical Engineering

Admission Requirements

An undergraduate degree in chemical engineering or, in most cases, mechanical engineering, with a cumulative grade point average (GPA) of at least 3.0 on a 4.0 scale is required. Applicants with:

1. a science degree,
2. an engineering degree in a discipline other than chemical or mechanical engineering, or
3. a GPA below 3.0 but at least 2.8, may be conditionally admitted to the program.

Conditions may involve completion of a bridge program designed on a case-by-case basis, and typically requiring taking extra bridge courses, as further explained below. Depending on the background of the student, admission conditions may additionally require taking undergraduate courses (e.g., chemistry) or graduate courses. Bridge and undergraduate courses do not count toward degree credit; graduate-level courses do.

Submission of Graduate Record Examination (GRE) scores is encouraged in all cases, and required of those seeking financial support and those whose last prior degree is from an institution outside the United States. International students must also submit scores from the Test of English as a Foreign Language (TOEFL). According to university policy, international students must achieve a minimum TOEFL score of 550 (pencil and paper); 213 (computer-based); 79 (internet-based).

The admission requirements described above can be partially relaxed for applicants with significant industrial experience in the pharmaceutical industry (5+ years). The admission requirements for such candidates will be established on a case-by-case basis, and will be determined through an interview with the prospective student and the submission of letters of support attesting the level of experience attained.

Bridge Program

The Pharmaceutical Engineering program has been designed so that applicants with different backgrounds can be admitted. Nevertheless, the program is strongly oriented toward the engineering component of "Pharmaceutical Engineering". In addition, since the pharmaceutical industry is a chemistry-based industry a chemical engineering background is the most appropriate to enter the program (mechanical engineers are also generally well prepared to enter the program). This implies that students who have a science background (e.g., chemistry or pharmacy B.S. degree) or an engineering degree in a discipline other than chemical or, possibly, mechanical engineering, may be required to take a bridge program.

NJIT Faculty

A

Armenante, Piero M., Distinguished Professor

B

Baltzis, Basil C., Professor

Barat, Robert B., Professor

Bilgili, Ecevit A., Assistant Professor

D

Dave, Rajesh N., Distinguished Professor

Dreyzin, Edward L., Professor

E

Engler, Peter, Associate Professor Emeritus

G

Gogos, Costas G., Distinguished Research Professor

H

Hanesian, Deran, Professor

Huang, Ching-Rong, Professor Emeritus

K

Khusid, Boris, Professor

Kristol, David, Professor Emeritus

L

Loney, Norman, Professor

P

Perlmutter, Howard D., Professor Emeritus

Perna, Angelo, Professor

Pfeffer, Robert, Distinguished Professor Emeritus

R

Roche, Edward C., Professor Emeritus

Rosty, Roberta, Senior University Lecturer

S

Schoenitz, Mirko, Associate Research Profess

Sebastian, Donald H., Professor

Shilman, Avner, Professor Emeritus

Simon, Laurent, Associate Professor

Sirkar, Kamalesh K., Distinguished Professor

Sofer, Samir, Professor Emeritus

T

Tomkins, Reginald P.T., Professor

V

Voronov, Roman S., Assistant Professor

W

Wang, Xianqin, Associate Professor

X

Xu, Xiaoyang, Assistant Professor

Programs

- Biopharmaceutical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/biopharmaceutical-ms/)
- Chemical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/chemical-ms/)
- Materials Science and Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-ms/)
- Pharmaceutical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-ms/)

Programs

- Chemical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/chemical-phd/)
- Materials Science & Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-phd/)

Programs

- Pharmaceutical Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-management-cert/)
- Pharmaceutical Manufacturing (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-manufacturing-cert/)
- Pharmaceutical Technology (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-technology-cert/)
- Polymers and Plastics (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/polymers-and-plastics-cert/)

Chemical and Materials Engineering Courses

CHE 501. Fundamentals of Chemical Engineering I. 6 credits, 6 contact hours.
Prerequisites: MATH 222 or equivalent, CHEM 231 or equivalent(see undergraduate catalog descriptions). An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include material and energy balances, thermodynamics, kinetics and reactor design, and staged separation processes. May not be taken for degree credit in any chemical engineering program.

CHE 502. Fundamentals of Chemical Engineering II. 4 credits, 4 contact hours.
Prerequisites: MATH 222 or equivalent (see undergraduate catalog for description), CHE 501 or equivalent. A continuation of CHE 501. An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include fluid mechanics, heat transfer and diffusion-controlled processes. May not be taken for degree credit in any chemical engineering program.

CHE 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

CHE 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services.

CHE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services.

CHE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CHE 599. Methods for Teaching Assistants and Graduate Assistants. 3 credits, 3 contact hours.
Restriction: graduate standing. Required for all chemical engineering teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

CHE 602. Selected Topics in Chemical Engineering I. 3 credits, 3 contact hours.
Restriction: graduate standing. Topics of current interest in chemical engineering.

CHE 603. Separation Process Principles. 3 credits, 3 contact hours.
Prerequisites: CHE 342, CHE 349, CHE 363, CHE 364, CHE 367, CHE 471. The course covers the basic principles of separation with or without chemical reaction in phase equilibrium-based, external field-driven and membrane-based separation processes.

CHE 604. Membrane Separation Processes. 3 credits, 3 contact hours.
Prerequisites: CHE 342, CHE 349, CHE 363, CHE 364, CHE 367, CHE 471. This course covers the science, technology, engineering analysis and design of membrane separation processes, membrane reactors, membrane-based equilibrium separation processes and hybrid membrane processes.

CHE 611. Thermodynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in physical chemistry and thermodynamics, or equivalent. Principles of thermodynamics developed quantitatively to include thermodynamic functions and their application to chemical engineering processes.

CHE 612. Kinetics of Reactions and Reactor Design. 3 credits, 3 contact hours.
Prerequisites: Undergraduate course in chemical engineering kinetics or equivalent. Elements of optimum design for various reactor types, multiple reactions, and temperature effects. Yield and selectivity optimization with emphasis on small-scale pharmaceutical production. Introduction to non-ideal reactor design. Study of various models for catalytic and non-catalytic solid-fluid reactions.

CHE 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy; near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

CHE 623. Heat Transfer. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in heat transfer. Heat transmission applied to practical problems in design. An introduction will include review of conduction, convection and radiation heat transfer modes. Related topics covered will be heat exchangers, types and design principles (including Kern & Bell?s methods), effectiveness, (NTU Design and Rating methods), Fired Heaters, Design & Rating and Cooling Towers, Design & Rating.

CHE 624. Transport Phenomena I. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in fluid mechanics, heat transfer, and mass transfer. A unified treatment of molecular and turbulent momentum, energy, and mass transport. Emphasis is on the mathematical description of physical mechanisms in momentum and energy transport.

CHE 626. Mathematical Methods in Chemical Engineering. 3 credits, 3 contact hours.
Prerequisites: MATH 222 or equivalent undergraduate degree in Chemical Engineering. The purpose of the course is to emphasize the importance of mathematics to chemical engineering practice. Applications of ordinary differential equations, Sturm-Liouville problems arising from partial differential equations, regular Perturbation approaches to some nonlinear systems of chemical engineering interests, use of Laplace transfroms expecially the Residue Theorem for inversions and some numerical methods. It is suggested that students take this course before taking CHE 624.

CHE 627. Introduction to Biomedical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in thermodynamics and differential equations. Introduction to the structure and composition of the body followed by an exploration of the properties of blood and its flow in the cardiovascular system; the body as a heat source and as a series of compartments involved in mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored. Same as BME 627.

CHE 628. Biochemical Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate degree in chemical engineering. The application of chemical engineering to biological processes, biochemical reaction systems, and their technological use. Special attention given to problems in momentum, energy, and mass transport, as well as chemical reaction kinetics in biological systems.

CHE 654. Corrosion. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in Chemistry. Fundamental principles including thermodynamics and kinetics of corrosion; forms of corrosion (e.g. galvanic, crevice and stress); methods of corrosion measurement; high temperature corrosion; and special case histories.

CHE 675. Statistical Thermodynamics. 3 credits, 3 contact hours.
Prerequisites: CHE 611 or permission of instructor. Application of equilibrium statistical mechanics to chemical engineering problems. Basic postulates and relationships of statistical thermodynamics, including the ideal gas, ideal crystal, and virial equation; statistical theories of fluid mixtures and other advanced topics.

CHE 681. Polymerization-Principles and Practice. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in physical or organic chemistry or CHE 503 or equivalent. The course focuses on the structural and synthetic aspects of polymers and examines in detail a number of bench and industrial scale polymerization methods. In addition to kinetics and mechanisms of commercially important polymerization systems, the course examines reactive modification of synthetic and natural polymers and provides an introduction to applicable characterization methods.

CHE 682. Polymer Structures and Properties. 3 credits, 3 contact hours.
Prerequisites: Undergraduate physical chemistry, a materials related course or CHE 503 or equivalent. The course provides an overview of polymer structures and properties and their relationships from the molecular viewpoint to phenomenological descriptions. Topics include thermodynamics of a single molecule, dynamic theory and viscoelasticity of polymers, polymer solids and mechanical properties, rubbers, polymer blends and composites, biological polymers, and special applications. New areas and innovative applications of polymers will be introduced.

CHE 683. Polymer Processing. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in transport phenomena, fluid flow, or heat transfer or approval of graduate advisor. The course provides a systematic approach to the physical phenomena occurring in polymer processing machinery. The synthesis of the elementary steps of polymer processing are shown in relation to the development of extrusion die flow and extrusion products and injection mold flows and molded products. Structural and residual stresses are examined.

CHE 684. Materials and Process Selection for Polymer Product Design. 3 credits, 3 contact hours.
Prerequisites or corequisites: CHE 681, CHE 682, CHE 683 or approval of graduate advisor. The course provides methodologies for designing polymer-based products by considering materials and processing methods. Methods for selecting homopolymers, polymer blends and composites for specific appilcations will be presented in terms of properties, processability, manufacturing methods and economics. Process/structure/property correlations are presented as well as approaches to product design including CAD, prototyping, and strength and failure criteria. Case studies from biomedical, packaging and other applications are discussed.

CHE 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering. A written report must be submitted to the project advisor. The student cannot register in CHE 700B more than once and the incomplete (I) grade is not allowed.

CHE 701B. Masters Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: CHE 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CHE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHE 701C. Masters Thesis. 6 credits, 6 contact hours.
Co-requisite for full-time students: CHE 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CHE 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CHE 702. Selected Topics in Chemical Engineering II. 3 credits, 3 contact hours.
Restriction: graduate standing. Topics of current interest in chemical engineering.

CHE 705. Independent Study. 3 credits, 3 contact hours.
Restriction: permission from the graduate advisor (not dissertation advisor) in chemical engineering. Students working on their PhD or MS theses cannot register for this course with their respective thesis advisors. This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHE 706. Independent Study II. 3 credits, 3 contact hours.
Pre-requisite: CHE 705. Restriction: permission from the graduate advisor (not dissertation advisor) in chemical engineering. Students working on their PhD or MS theses cannot register for this course with their respective thesis advisors. This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHE 709. Adv Separation Processes. 3 credits, 3 contact hours.
Prerequisites: CHE 360, CHE 460, CHE 612, CHE 624 and CHE 626 or permission of instructor. Students having a background in undergraduate separations courses will be introduced to advanced concepts in separations. These include: descriptions of separation; forces causing separation in equilibrium, field and membrane separation processes; flux-force relations; chemical potential profiles; role of chemical reactions in separations; four different combinations of directions of force and bulk motions in separators; time-dependent processes. Advanced analysis of important individual separation processes of three types, namely, equilibrium-based, membrane-based and external field-based processes will be carried out.

CHE 710. Adv Membrane Separation Proc. 3 credits, 3 contact hours.
Prerequisites: CHE 460, CHE 603, CHE 624, CHE 626 or permission of instructor. This course will provide advanced treatments of science, technology, engineering analysis and design of the following membrane separation processes: reverse osmosis, nanofiltration, ultrafiltration, dialysis, electrodialysis, Donnan dialysis, liquid membrane permeation, microfiltration, gas permeation through polymeric membranes, pervaporation, membrane-based equilibrium separation processes, membrane reactors and hybrid membrane processes. Membrane structure/function and device design for each technology are of interest.

CHE 714. Micromechanics of Part Tech Pr. 3 credits, 3 contact hours.
Prerequisites: CHE 624 or equivalent Corequisites: PHEN 601 or equivalent (not required but suggested) Presents methodologies for analyzing the macroscopic properties of particulate systems. Includes characterization and processing of particulate systems at the microlevel, predicting macroscopic properties from microlevel models, and analysis of particulate manufacturing processes involving solids processing, such as solids characterization, blending, milling, granulation, tableting, etc. Course includes laboratory demonstrations and a class project involving use of surface modification.

CHE 721. Combustion Reaction Engineering. 3 credits, 3 contact hours.
Restriction: undergraduate degree in Chemical or Mechanical Engineering. Topics related to the engineering of combustion systems will be discussed. These include laminar flames, turbulent combustion, ideal reactor modeling of complex combustion systems, combustion chemistry, heterogeneous combustion and incineration.

CHE 722. Additive Manufacturing & Appl. 3 credits, 3 contact hours.
Prerequisites: CHE 624 and CHE 626 are both prerequisites or can be taken concurrently. Other equivalent courses can be acceptable for non-chemical engineering students with permission of the instructor. This course describes additive manufacturing technologies and current (and emerging) applications of 3D printing. The course will be composed of a lecture and a hands-on laboratory session, during which students will create 3D designs and print functional prototypes.

CHE 724. Sustainable Energy. 3 credits, 3 contact hours.
The course is a project-based advanced graduate course which requires strong background in engineering thermodynamics and transport phenomena. The main goals of this course are to gain an understanding of the cost-benefit ratio of various alternative energy sources and to understand some of the various obstacles associated with current and conventional technologies and industrial applications. Different renewable and conventional energy technologies will be discussed in class. Course materials include biomass energy, fossil fuels, geothermal energy, nuclear power, wind power, solar energy, hydrogen fuel, hydropower, and fuel cells. Students will learn a quantitative framework to aid in evaluation and analysis of energy technology systems in the context of engineering, political, social, economic, and environmental goals.

CHE 725. Transport Phenomena II. 3 credits, 3 contact hours.
Prerequisite: CHE 624 or equivalent. Transport in laminar and turbulent flow: in solids, between phases, and macroscopic transport in flow systems.

CHE 734. Chem Process Dynamic & Control. 3 credits, 3 contact hours.
Prerequisite: CHE 626 or equivalent. Corequisites: CHE 611, CHE 612 or equivalent Mathematical principles of process dynamics and control; derivation and solution of differential equations describing the behavior of typical chemical engineering processing units; and mathematical analysis and design of control systems. Digital and sampled data control systems also discussed.

CHE 750. Environmental Catalysis. 3 credits, 3 contact hours.
Prerequisites: CHE 612 or equivalent. An introduction to catalytic processes used for environmental abatement. The course provides background information necessary to understand environmental catalytic processes. Mobile and stationary pollution abatement technologies are reviewed.

CHE 756. Industrial Catalysis. 3 credits, 3 contact hours.
Prerequisites: CHE 612 or equivalent. The class provides an introduction to catalytic phenomena as well as catalysts with the background information necessary to understand industrial catalytic processes. Examples discussed are hydrogen, ammonia and methanol synthesis, inorganic and organic oxidation reactions, petrochemical processes, pollution abatement and other important processes. The course provides insight into the theory of catalytic phenomena and information about related technologies from an industrial perspective.

CHE 775. Molecular Simulations in CHE. 3 credits, 3 contact hours.
Prerequisites: CHE 611 and CHE 626. Minimal programming experience in any programming language (e.g. Matlab, Python or Fortran). The course is aimed to introduce graduate students to the basics of molecular simulation. Two simulation techniques will be discussed in detail: Monte Carlo and molecular dynamics methods. The students will study the algorithms, and the statistical mechanics basis of these algorithms. Then they will use popular open source codes to simulate systems relevant for chemical engineers.

CHE 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Co-Requisite: CHE 791. For students admitted before Fall 2015. Required of all students for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

CHE 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have passed the Qualifying Examination and Research Proposal. Required of all students for the degree of Doctor of Philosophy. Approval of dissertation advisor is necessary for registration. Experimental or theoretical investigation of a topic in chemical engineering. Students must register for 1 credit of dissertation per semester until a written dissertation is approved.

CHE 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have passed the Qualifying Examination but have not defended Research Proposal. Required of all students for the degree of Doctor of Philosophy. Approval of dissertation advisor is necessary for registration. Experimental or theoretical investigation of a topic in chemical engineering. Students must register for 3 credits of dissertation per semester after passing Qualifying Examination until they successfully defend their Research Proposal.

CHE 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.

CHE 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CHE 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CHE 790F. Dissertation & Res. 15 credits, 3 contact hours.

CHE 790G. Doct Dissertatopm & Resrch. 18 credits, 0 contact hours.

CHE 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all chemical engineering students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

CHE 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite for full time students: CHE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in chemical engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well, for students who have completed the required coursework but have not passed the qualifying examination.

CHE 792C. Pre-Doctoral Research. 6 credits, 0 contact hours.

CHE 794. Professional Presentations for Ph.D. Students. 0 credits, 0 contact hours.
Intended to help students make better technical presentations. Each student is required to make a presentation on a research topic; guest lectures will occur during the semester.

CHE 795. Research Methods for Doctoral. 3 credits, 3 contact hours.
Prerequisites: Doctoral standing in CBPE or permission of the instructor. This course is designed to enhance professional development of our doctoral students in order to significantly increase their research productivity, communications, and leadership skills while preparing them for a successful career. Concepts include setting priorities, time management, and learning best practices in research planning, execution, communication, writing and presentation. Advanced topics include understanding innovation, intellectual property and writing better proposals.

PHEN 500. Pharmaceutical Engineering Fundamentals I. 3 credits, 3 contact hours.
Prerequisite: undergraduate calculus. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree. This course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of calculus, differential equations, probability and statistics, and finance business mathematics applied to pharmaceutical engineering problems and illustrated through pharmaceutical engineering examples.

PHEN 501. Pharmaceutical Engineering Fundamentals II. 3 credits, 3 contact hours.
Prerequisite: If needed, PHEN 500 (which can also be taken concurrently with this course), as well as an undergraduate course in physical chemistry. This course is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of pharmaceutical engineering calculations related to material and energy balances applied to pharmaceutical facilities and systems; estimation of thermophysical properties, phase and reaction equilibrium; and chemical kinetics and basic reactor design.

PHEN 502. Pharmaceutical Engineering Fundamentals III. 3 credits, 3 contact hours.
Prerequisite:If needed, PHEN 500 and PHEN 501, as well as undergraduate course in physical chemistry. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of fluid mechanics, heat transfer, mass transfer and the design of unit operations involving these principles.

PHEN 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations at pharmaceutical companies or companies serving the pharmaceutical industry. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

PHEN 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Same range of activities as in PHEN 590.

PHEN 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Same range of activities as in PHEN 590 and PHEN 591.

PHEN 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisites: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

PHEN 601. Principles of Pharmaceutical Engineering. 3 credits, 3 contact hours.
This course provides an overview of the pharmaceutical industry, including basic information about drug discovery and development, FDA requirements and approval processes, drug dosage forms, and the role of key operational units in drug manufacturing processes. This course enables the students to: understand the role of the pharmaceutical industry in the global market and its implications; learn the fundamentals of the drug development cycle and the investment required to bring a drug to market; learn the most important drug manufacturing processes and the key elements of dosage formulation.

PHEN 602. Pharmaceutical Facility Design. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603; undergraduate courses in differential equations and fluid flow or completion of bridge program for students who are required to take it. This course provides instruction in design of state-of-the art pharmaceutical facilities for both manufacturing and R&D, by identifying key functional requirements and design concepts necessary to pharmaceutical processes. Interdisciplinary training will be provided in appropriate areas of facility design.

PHEN 603. Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems. 3 credits, 3 contact hours.
This course examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving liquid and dispersed-phase systems, such as liquid and multiphase mixing, sterilization and sanitation, lyophilization, filtration, centrifugation and others. The emphasis is primarily on the engineering aspects of the parmaceutical processes examined in the course.

PHEN 604. Validation and Regulatory Issues in the Pharmaceutical Industry. 3 credits, 3 contact hours.
This course is focused on the development of a working knowledge of the Federal Code of Regulations and its impact on the pharmaceutical and allied industries. The history of the Federal Government's regulation of the pharmaceutical industry is studied. Also covered is the industry's response and the methodologies it uses to comply with these regulations.

PHEN 605. Pharmaceutical Packaging Technology. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603, and completion of the bridge program for students who are required to take it. This course focuses on developing a working knowledge of the machinery and unit operations used in transferring a drug substance in the bulk final form to a finished product ready for sale to the consuming public. Packaging of both liquid and solid forms in various types of delivery containers such as vials/ampoules, blister packs, individual packets, bottles, pouches and syringes is examined. The cleaning, sterilization and scaling/capping required for each dosage form is discussed, as well as freeze-drying, tableting capsule filling, and form/fill/seal, and proper labeling of final drug forms.

PHEN 606. Pharmaceutical Unit Operations: Solids Processing. 3 credits, 3 contact hours.
This course examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving solids processing, such as solids characterization, blending, milling, granulation, tableting, coating, and others. The emphasis is primarily on the engineering aspects of the pharmaceutical processes examined in the course.

PHEN 612. Pharmaceutical Reaction Engineering. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603; undergraduate courses in differential equations and chemical engineering kinetics, or completion of bridge program for students who are required to take it. This course examines a variety of reactions and reactors typically encountered in the pharmaceutical industry, including single/multiphase systems (e.g., crystallization), chemical synthesis, enzymatic, bio-reactions (fermentation), and others. The course then focuses on quantitative pharmaceutical reactor design and scale-up issues.

PHEN 614. Pharmaceutical Separation Processes. 3 credits, 3 contact hours.
This course covers separation processes in general and pharmaceutical separations in particular. Specific processes to be studied include distillation, extraction, crystallization, adsorption, ion exchange, chromatography, moving bed processes, electrophoresis, freeze drying, microfiltration/ultrafiltration, reverse osmosis, and pervaporation.

PHEN 618. Principles of Pharmacokinetics and Drug Delivery. 3 credits, 3 contact hours.
The course covers the basic principles of pharmacokinetics, including drug transport, parenteral and enteral routes of drug administration, and factors affecting drug absorption, distribution, metabolism, and excretion. Mathematical pharmacokinetic models and drug delivery processes are also presented and quantitatively studied.

PHEN 698. Special Topics in Pharmaceutical Engineering I. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 699. Special Topics in Pharmaceutical Engineering II. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the Master's degree in pharmaceutical engineering. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the pharmaceutical engineering faculty, and one other faculty member. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHEN 701B. Master'S Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: PHEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in pharmaceutical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in PhEn 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHEN 701C. Master'S Thesis. 6 credits, 3 contact hours.
Corequisite for full-time students: PHEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in pharmaceutical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (PHEN 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHEN 702. Selected Topics in Pharmaceutical Engineering. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 725. Independent Study. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

PHEN 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for PHEN 726 if they have taken PHEN 725 in a prior semester. Students cannot register for this course with the same advisor as they had in PHEN 725.

PHEN 791. Graduate Seminar. 0 credits, 0 contact hours.
Required, when offered, of all pharmaceutical engineering graduate students receiving departmental or research-based awards. The student must register each semester until completion of the degree, if the Graduate Seminar is offered. Outside speakers and department members present their research for general discussion.

M.S. in Biopharmaceutical Engineering

Bridge Program

Depending on the background of the applicant, the bridge program may consist of up to (but generally speaking less than, at least for students with engineering degrees) three 3-credit courses specifically designed to provide non-chemical engineers with the necessary prerequisites to enter the program.

A grade point average of at least 3.0 must be achieved in the bridge courses. Students should pay special attention to the successful completion of the bridge courses, since failure to do so may preclude them from enrolling in regular PhEn courses. Students must take the bridge courses before taking any other PhEn courses, with the exception of PHEN 601 Principles of Pharmaceutical Engineering and PHEN 604 Validation and Regulatory Issues in the Pharmaceutical Industry, which can be taken concurrently with the bridge courses. As mentioned, admission conditions may also include taking undergraduate or graduate courses, if needed.

Degree Requirements

The Master of Science in Biopharmaceutical Engineering is a 30-credit program, including 21 credits worth of core courses. Students have the option of fulfilling six (6) of the nine (9) credit of electives by doing a Master's Thesis. The thesis option is primarily, but not exclusively, meant for full time students. Full-time students receiving support (full or partial) must complete a Master's Thesis. Part-time students working in the Pharmaceutical industry are encouraged to pursue a Master's Thesis, possibly conducted at their and in collaboration with their supervisor.

Students must maintain an overall cumulative grade point average of at least 3.0 throughout their academic career.

Students are certified for graduation only if they:

- Achieve an overall cumulative grade point average of at least 3.0; and
- Achieve a grade point average of at least 3.0 in the required core courses; and
- Achieve a grade point average of at least 3.0 in the bridge courses (if taking the bridge courses is required).

Students may not repeat a course without approval of both the Program Director and the Office of Graduate Studies. If a student repeats a course, the grades received in the first two repeated courses will replace the original grades in the calculation of the cumulative grade point average, although the old grades will still appear on the transcripts. However, the grades received in all repeated courses beyond the first two will count in the calculation of the cumulative grade point average. Students who receive an F in a course are required to repeat the course.

Program of Study/Curriculum

A minimum of 30 credits is required for degree completion. Of these, 21 credits must be obtained by taking seven (7) prescribed Core Courses, which include Pharmaceutical Bioprocessing (PhB) courses as well as Pharmaceutical Engineering (PhEn) courses. In addition, engineering applicants with little or no biology background, but not biology or pharmacy applicants, may be required to take an additional Foundation Course (PHB 505 Principles of Pharm. Microbiology and Biochemistry), which will count toward the 30 credits required to complete the PhB program. The remaining credits needed to achieve the required 30 credits may be obtained by taking either elective courses only or a combination of an elective course and M.S. Thesis credits. As already indicated, applicants with a science background or an engineering degree in a discipline other than chemical engineering may be required to additionally take one or more bridge courses. Bridge courses do not count toward the 30 credits required to complete the program.

Course Requirements

M.S. in Biopharmaceutical Engineering (non-engineering applicants with little or no biology background, courses only)

Code	Title	Credits
Bridge Courses		
PHEN 500	Pharmaceutical Engineering Fundamentals I [1]	3
PHEN 501	Pharmaceutical Engineering Fundamentals II [1]	3
PHEN 502	Pharmaceutical Engineering Fundamentals III	3
Total Credits		9

[1] PHEN 500 Pharmaceutical Engineering Fundamentals I and PHEN 501 Pharmaceutical Engineering Fundamentals II should be taken concurrently.

Code	Title	Credits
Foundation Course		
PHB 505	Principles of Pharm. Microbiology and Biochemistry	3
Core Courses		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 603	Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems	3
PHEN 618	Principles of Pharmacokinetics and Drug Delivery	3
PHB 610	Biotechnology-Biopharmaceutical, Processes and Products	3
PHB 615	Bioseparation Processes	3
PHB 630	Pharmaceutical Bioprocess Engineering	3
Electives		
Elective courses [1]		6
Total Credits		30

[1] Partial list of approved electives is in Electives table. Electives can be selected from among *appropriate* courses in disciplines including but not limited to pharmaceutical engineering, chemical engineering, mechanical engineering, industrial engineering, engineering management, pharmaceutical system management, biomedical engineering, chemistry, biology, mathematics and others. Students are encouraged to choose electives from a variety of offering departments. In general, all technical and scientific courses that are relevant to the program could be selected, typically in consultation with the Program Advisor.

M.S. in Biopharmaceutical Engineering (non-engineering applicants with little or no biology background, Master's thesis)

Code	Title	Credits
Bridge Courses		
PHEN 500	Pharmaceutical Engineering Fundamentals I [1]	3
PHEN 501	Pharmaceutical Engineering Fundamentals II [1]	3
PHEN 502	Pharmaceutical Engineering Fundamentals III	3
Total Credits		9

[1] PHEN 500 Pharmaceutical Engineering Fundamentals I and PHEN 501 Pharmaceutical Engineering Fundamentals II should be taken concurrently.

Code	Title	Credits
Foundation Course		
PHB 505	Principles of Pharm. Microbiology and Biochemistry	3
Core Courses		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 603	Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems	3
PHEN 618	Principles of Pharmacokinetics and Drug Delivery	3
PHB 610	Biotechnology-Biopharmaceutical, Processes and Products	3
PHB 615	Bioseparation Processes	3
PHB 630	Pharmaceutical Bioprocess Engineering	3
Thesis		
PHB 701 Master's Thesis [1]		6
Total Credits		30

[1] Must register during the last semester before graduation, even if this requires taking additional thesis credits beyond the required six (6) credits.

M.S. in Biopharmaceutical Engineering (courses only)

Code	Title	Credits
Core Courses		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 603	Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems	3
PHEN 618	Principles of Pharmacokinetics and Drug Delivery	3
PHB 610	Biotechnology-Biopharmaceutical, Processes and Products	3
PHB 615	Bioseparation Processes	3
PHB 630	Pharmaceutical Bioprocess Engineering	3
Electives		
Elective courses [1]		9
Total Credits		30

[1] Partial list of approved electives is in Electives table. Electives can be selected from among *appropriate* courses in disciplines including but not limited to pharmaceutical engineering, chemical engineering, mechanical engineering, industrial engineering, engineering management, pharmaceutical system management, biomedical engineering, chemistry, biology, mathematics and others. Students are encouraged to choose electives from a variety of offering departments. In general, all technical and scientific courses that are relevant to the program could be selected, typically in consultation with the Program Advisor.

M.S. in Biopharmaceutical Engineering (Master's thesis)

Code	Title	Credits
Core Courses		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 603	Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems	3
PHEN 618	Principles of Pharmacokinetics and Drug Delivery	3
PHB 610	Biotechnology-Biopharmaceutical, Processes and Products	3
PHB 615	Bioseparation Processes	3
PHB 630	Pharmaceutical Bioprocess Engineering	3
Thesis		
PHB 701 Master's Thesis [1]		6
Electives		
Elective course [2]		3
Total Credits		30

1 Must register during the last semester before graduation, even if this requires taking additional thesis credits beyond the required six (6) credits.

2 Partial list of approved electives is in Electives table. Electives can be selected from among *appropriate* courses in disciplines including but not limited to pharmaceutical engineering, chemical engineering, mechanical engineering, industrial engineering, engineering management, pharmaceutical system management, biomedical engineering, chemistry, biology, mathematics and others. Students are encouraged to choose electives from a variety of offering departments. In general, all technical and scientific courses that are relevant to the program could be selected, typically in consultation with the Program Advisor.

Electives

Code	Title	Credits
PHEN 698	Special Topics in Pharmaceutical Engineering I	3
PHEN 699	Special Topics in Pharmaceutical Engineering II	3
PHB 701B	Master's Thesis	3
PHB 701C	Master's Thesis	6
PHB 725	Independent Study I	3
PHEN 602	Pharmaceutical Facility Design	3
PHEN 605	Pharmaceutical Packaging Technology	3
PHEN 606	Pharmaceutical Unit Operations: Solids Processing	3
PHEN 612	Pharmaceutical Reaction Engineering	3
PHEN 614	Pharmaceutical Separation Processes	3
BME 651	Principles of Tissue Engineering	3
BME 672	Biomaterials	3
CHE 611	Thermodynamics	3
CHE 624	Transport Phenomena I	3
CHE 626	Mathematical Methods in Chemical Engineering	3
CHE 675	Statistical Thermodynamics	3
CHE 681	Polymerization-Principles and Practice	3
CHEM 601	Special Topics in Chemistry I (Special Topics in Chemistry I)	3
CHEM 605	Advanced Organic Chemistry I: Structure	3
CHEM 606	Physical Organic Chemistry	3
CHEM 658	Advanced Physical Chemistry	3
CHEM 661	Instrumental Analysis Laboratory	3
CHEM 664	Advanced Analytical Chemistry	3
CHEM 673	Biochemistry	3
EM 636	Project Management	3
EM 637	Project Control	3
EM 640	Distribution Logistics	3
IE 604	Advanced Engineering Statistics	3

IE 605	Engineering Reliability	3
IE 618	Engineering Cost and Production Economics	3
IE 672	Industrial Quality Control	3
IE 673	Total Quality Management	3
IE 674	Quality Maintenance and Support Systems	3
IE 704	Sequencing and Scheduling	3
MATH 613	Advanced Applied Mathematics I: Modeling	3
MATH 635	Analytical Computational Neuroscience	3
MATH 637	Foundations of Mathematical Biology	3
MATH 654	Clinical Trials Design and Analysis	3
MATH 661	Applied Statistics	3
MATH 663	Introduction to Biostatistics	3
MATH 664	Methods for Statistical Consulting	3
R120 512	Cell Biology: Methods & Appl	3
R120 515	Molecular Bio Of Eukaryotes	3
R120 601	Human Molecular Genetics	3

M.S. Thesis

Full-time students receiving full or partial financial support must complete a Master's Thesis. Part-time students can also complete a Master's Thesis if they so choose. Part-time students working in industry are also eligible, and encouraged, to pursue the thesis option, possibly even conducted at their site and in collaboration with their supervisor. Students doing a thesis must select a Thesis Advisor who will guide them trough their thesis work. The students must also complete a form indicating the three (3) faculty members composing their MS Thesis Committee, to be selected in consultation with their Thesis Advisor. Students who are required, or choose, to do a thesis must take six (6) credits of PHB 701 Master's Thesis in lieu of six (6) credits worth of electives courses, and must choose their remaining elective course(s) in concultation with their Thesis Advisor. NJIT requires that students who elect to do a thesis must register for thesis during the last semester before graduation, even if this requires taking addition thesis credits beyond the required six (6) credits. Completion of the thesis requirements also includes:

1. writing the thesis document, to be approved by the Thesis Committee, and
2. making a final oral presentation to the MS Thesis Committee.

Student Involvement in Research

In addition to taking courses, students have the opportunity to work, one-on-one, with faculty members on research projects in areas of common interest, allowing maximum flexibility for independent work, and providing students with valuable research experience. Students have the option to complete a Master's Thesis. Part-time students working in the pharmaceutical industry are encouraged to pursue a Master's Thesis, possibly conducted at their site and in collaboration with their supervisor.

Qualified and research oriented students have the option of continuing their studies at NJIT by pursuing a Ph.D. in chemical engineering, industrial engineering, chemistry, or related disciplines. The NJIT-Industry Collaborative Ph.D. Program allows greater flexibility to industrial students who are interested in pursuing their Ph.D. while working *full-time* in industry.

M.S. in Chemical Engineering

Degree Requirements

A minimum of 30 credits is required. Students must attain a minimum GPA of 3.0 in the core courses listed below, and a minimum overall GPA of 3.0.

Degree Options

M.S. in Chemical Engineering (courses only)

Code	Title	Credits
Core Courses		
CHE 611	Thermodynamics	3
CHE 612	Kinetics of Reactions and Reactor Design	3
CHE 624	Transport Phenomena I	3
CHE 626	Mathematical Methods in Chemical Engineering	3
Elective Courses		
Two electives in chemical engineering		6

Two electives in any engineering, science, or mathematics area including but not limited to chemical engineering	6
Two Elective courses (any subject area)	6
Total Credits	30

[1] 500-level courses offered in the department do not count toward degree requirements.

M.S. in Chemical Engineering (students receiving departmental or research-based support)

Code	Title	Credits
Core Courses		
CHE 611	Thermodynamics	3
CHE 612	Kinetics of Reactions and Reactor Design	3
CHE 624	Transport Phenomena I	3
CHE 626	Mathematical Methods in Chemical Engineering	3
Thesis [1]		
CHE 700B	Masters Project	3
CHE 701B	Masters Thesis	3
Seminar		
CHE 791	Graduate Seminar [2]	0
Elective Courses		
One elective in Chemical Engineering		3
One elective in Engineering, Science, or Mathematics area including but not limited to Chemical Engineering		3
Two Elective courses (any subject area)		6
Total Credits		30

[1] Before deciding on a thesis topic and advisor, students must discuss thesis topics with at least three faculty members and get their signature on a form provided by the department. The signed form with the name of advisor selected and tentative title of thesis topic must be returned to the department for approval. Change of advisor requires consent of the previous advisor and departmental approval. The completed thesis must be examined and signed by three faculty members at least two of which must be on the department faculty. An oral presentation is also required. The MS thesis committee must be formed and submitted to the department for approval at least one semester before the expected graduation date. The department provides a form for the formation of the MS thesis committee.

[2] All students who receive departmental or research-based support must enroll each semester in CHE 791 Graduate Seminar.

[3] 500-level courses offered in the department do not count toward degree requirements.

M.S. in Chemical Engineering (Master's thesis)

Code	Title	Credits
Core Courses		
CHE 611	Thermodynamics	3
CHE 612	Kinetics of Reactions and Reactor Design	3
CHE 624	Transport Phenomena I	3
CHE 626	Mathematical Methods in Chemical Engineering	3
Thesis [1]		
CHE 701B & 701B	Masters Thesis and Masters Thesis	6
or CHE 701C	Masters Thesis	
Seminar		
CHE 791	Graduate Seminar	0
Elective Courses		
One elective in Chemical Engineering		3
One elective in any Engineering, Science, or Mathematics area including but not limited to Chemical Engineering		3
Two elective courses (any subject area)		6
Total Credits		30

1 Before deciding on a thesis topic and advisor, students must discuss thesis topics with at least three faculty members and get their signature on a form provided by the department. The signed form with the name of advisor selected and tentative title of thesis topic must be returned to the department for approval. Change of advisor requires consent of the previous advisor and departmental approval. The completed thesis must be examined and signed by three faculty members at least two of which must be on the department faculty. An oral presentation is also required. The MS thesis committee must be formed and submitted to the department for approval at least one semester before the expected graduation date. The department provides a form for the formation of the MS thesis committee.

2 All students who receive departmental or research-based support must enroll each semester in CHE 791 (http://catalog.njit.edu/archive/2019-2020/search/?P=CHE%20791) Graduate Seminar.

M.S. in Materials Science and Engineering

The program is offered in two options, the Materials Science option and the Materials Engineering option. These options are administered by the CSLA (College of Science and Liberal Arts) and NCE (Newark College of Engineering) colleges, respectively. A joint committee involving CSLA and NCE faculty will be in charge of overseeing this program.

Materials Engineering Option

Administered by the Chemical and Materials Engineering Department, NCE

The master's degree is a valued professional credential, offered on a full-time or part-time basis. Applicants are expected to have a baccalaureate degree in engineering (chemical, mechanical, electrical, civil, or biomedical) or in physics or chemistry or equivalent with a minimum GPA of 3.0. Students with undergraduate degrees in biology or other STEM disciplines may also be admitted on condition that additional bridge courses may be required. International students must achieve a TOEFL score of at least 550 (paper-based); 213 (computer-based); 79 (internet-based). A quantitative section of GRE must be at the level approved by NCE.

Thirty credit hours are required for the degree. A thesis is optional.

Cross-listed courses

Any cross-listed courses will not be offered simultaneously, but only one of the two will be offered at a time.

Code	Title	Credits
Core Courses		
MTEN 610	Found of Materials Sci & Engr	3
or MTSE 601	Fundamentals of Engineering Materials	
MTEN 611	Diffusion & Solid State Kineti	3
or MTSE 655	Diffusion and Solid State Kinetics	
MTEN 612	Thermodynamics of Materials	3
or MTSE 602	Thermodynamics of Materials	
MTEN 613	Characterization of Materials	3

Elective courses by tracks (6 credits)

Electives fit different tracks. Each track includes at least four courses. At least two courses from one of the tracks must be taken. Exceptions are to be approved by the Program Advisor.

Tracks

Code	Title	Credits
Soft materials and polymer composites		
MTSE 681	Composite Materials	
BME 672	Biomaterials	
CHE 681	Polymerization-Principles and Practice	
ME 679	Polymer Processing Techniques	
Hard materials and alloys		
ME 626	Fatigue Fracture of Solids	
ME 620	Mechanics of Materials	
MTSE 725	Crystallography and Diffraction	
ME 675	Mechanics of Fiber Composites	
CHE 702	Selected Topics in Chemical Engineering II	

ME 621	Advanced Mechanics of Material	
Nanomaterials/macromolecules/interfaces		
CHE 619	Nano-scale Characterization of Materials	
CHE 714	Micromechanics of Part Tech Pr	
MTEN 711	Nanocomposite Materials	
MTEN 712	Nanomaterials	
or CHEM 748	Nanomaterials	
Electronic and photonic materials		
MTSE 722	Science and Technology of Thin Films	
ECE 657	Semiconductor Devices	
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices	
ECE 626	Optoelectronics	

Other electives and MS thesis (12 credits: four courses or two courses and thesis)

Code	Title	Credits
Courses listed above from various tracks can be taken as electives. Additional electives include:		
CHE 722	Additive Manufacturing & Appl	
CHE 654	Corrosion	
CHE 750	Environmental Catalysis	
CHE 709	Adv Separation Processes	
CHE 710	Adv Membrane Separation Proc	
CHE 702	Selected Topics in Chemical Engineering II	
CHE 682	Polymer Structures and Properties	
CHE 683	Polymer Processing	
CHE 684	Materials and Process Selection for Polymer Product Design	
CHE 756	Industrial Catalysis	
BME 651	Principles of Tissue Engineering	
BME 680	BioMEMS Design and Applications	
ME 678	Engineering Design of Plastic Products	
ME 679	Polymer Processing Techniques	
ME 714	Principles of Particulate Multiphase Flows	
CE 632	Prestressed Concrete Design	
CE 636	Mechanics and Stability of Structures	
CE 641	Engineering Properties of Soils	
MTSE 681	Composite Materials	
MTEN 700B	Master's Project	
MTEN 701B	Masters Thesis	

M.S. in Pharmaceutical Engineering

The master's degree is a valued professional credential, offered on a full-time or part-time basis. Applicants are expected to have a baccalaureate degree in chemical engineering or equivalent with a minimum GPA of 3.0. Students with undergraduate degrees in biology, chemistry, physics, and equivalent may also be admitted on condition that additional undergraduate courses, specified at the time of admission, be taken and successfully completed. International students must achieve a TOEFL score of at least 550 (paper-based); 213 (computer-based); 79 (internet-based). A quantitative section of GRE must be at the level approved by NCE, presently at 155.

Thirty credit hours are required for the degree. A thesis is optional.

Code	Title	Credits
Core Courses (5 courses=15 credits):		
CHE 612	Kinetics of Reactions and Reactor Design	3
CHE 624	Transport Phenomena I	3
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 603	Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems	3

PHEN 618	Principles of Pharmacokinetics and Drug Delivery	3
Select at least one from these courses (1 course=3 credits):		
CHE 714	Micromechanics of Part Tech Pr	3
CHE 611	Thermodynamics	3
CHE 603	Separation Process Principles	3
Select at least one from these courses (1 course=3 credits):		**3**
PHEN 602	Pharmaceutical Facility Design	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 605	Pharmaceutical Packaging Technology	3
Select any combination of three elective courses/thesis courses/project course from the following list (3 courses=9 credits):		**9**
Any of the courses already listed above but not yet taken		3
Any courses from the programs specified below:		3
Pharmaceutical Engineering (PhEn) (such as courses not taken already)		
Chemical Engineering (ChE)		
Biomedical Engineering (BME)		
Biology (BIOL)		
Chemistry (CHEM)		
Biopharmaceutical Engineering (PhB)		
Pharmaceutical Materials Processing (PhMP)		
Pharmaceutical Systems Management		
Industrial Engineering (IE)		
Engineering Management (EM)		
Mathematics (MATH)		
Project/Independent Study		3
Thesis		6

Ph.D. in Chemical Engineering

Degree Requirements

To graduate, students must have an approved dissertation and attain an overall GPA of at least 3.0. Students need always to get departmental approval for the courses they take for their degree requirements.

Ph.D. in Chemical Engineering (students with master's in chemical engineering)

Code	Title	Credits
Electives		
700-level courses		12
Dissertation		
CHE 790 Doct Dissertation & Res [2]		
Seminar		
CHE 791	Graduate Seminar [3]	0
Total Credits		12

1. No more than 6 credits may be CHE 705 Independent Study. No more than 3 credits in CHE 705 Independent Study may be taken with the same supervising faculty member. The supervising faculty member may never be the student's dissertation advisor. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval.
2. Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (CHE 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal. Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (CHE 790 Doct Dissertation & Res) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.
3. Students must register every semester for this seminar. Part-time students may request that this requirement be waived for some semesters.

Ph.D. in Chemical Engineering (students without master's in chemical engineering)

Code	Title	Credits
Required Courses [1]		
CHE 611	Thermodynamics	3
CHE 612	Kinetics of Reactions and Reactor Design	3
CHE 624	Transport Phenomena I	3
CHE 626	Mathematical Methods in Chemical Engineering	3
Electives		
700-level chemical engineering or chemistry courses		6
700-level courses [2]		6
Electives		12
Dissertation		
CHE 790 Doct Dissertation & Res [3]		
Seminar		
CHE 791	Graduate Seminar [4]	0
Total Credits		36

1 Must attain a minimum GPA of 3.0 in the required courses.

2 No more than 6 credits may be CHE 705 Independent Study. No more than 3 credits in CHE 705 Independent Study may be taken with the same supervising faculty member. The supervising faculty member may never be the student's dissertation advisor. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval.

3 Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (CHE 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal. Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (CHE 790 Doct Dissertation & Res) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.

4 Students must register every semester for this seminar. Part-time students may request that this requirement be waived for some semesters.

Selection of Dissertation Advisor

Students must select a dissertation topic and advisor within 6 months of joining the program. Before making a decision, students should discuss research topics with at least five faculty members of the department and get their signature on a form provided by the department. The signed form with the names of advisors selected must be returned to the department for further processing. Advisors are assigned based on student preferences and availability of funding. Change of advisor requires consent of the previous advisor and departmental approval. In cases where more than one advisor is directing the dissertation, the primary advisor must be on the departmental faculty.

Qualifying Examination

All PhD candidates must pass a qualifying examination. Students must take the examination by the end of the second semester after enrolling in the PhD program. If repeated examination is necessary, the examination must be passed by the end of the third semester after enrolling in the PhD program.

Pre-requisites for the qualifying examination:

- Average grade of 3.5 for all four core courses and a minimum grade B in each of the core courses taken at NJIT

- Equivalent grade for the same subject course based on the MS transcript from an institution other than NJIT may be acceptable, as decided by the Graduate Studies Committee
- Students whose subject courses differ from those offered at NJIT, so that their MS transcript grades are not deemed acceptable as equivalent to the NJIT core courses by the Graduate Studies Committee are required to take final examinations for each of the core courses during their first two semesters after enrolling into PhD program to satisfy the present requirement.

- A student can take the final examination in each core course up to two times to satisfy the present requirement.

- Failing the present requirement is equivalent to the failing the qualifying examination.

Qualifying examination format

The examination is administered by an Examination Committee including at least three members of the CBPE graduate faculty. The Examination Committee is appointed by the Graduate Studies Committee each semester. The Examination Committee does not include the student's current or potential PhD thesis adviser.

Three months before the examination date, an assignment is given to a student to prepare for the qualifying examination. The assignment is given by the student's current or potential PhD thesis adviser in coordination with Examination Committee. The assignment identifies a research topic to be addressed in two parts of the examination:

- A written paper, comprising a literature review (no longer than 20 pages excluding references; 12 pts font, double spaced) on the identified research topic. The review needs to

- Identify an open research problem,
- Outline state of the art, and
- Propose an approach for future research in this area.
- If pertinent, results of preliminary work may be included.

- An oral presentation no longer than 20 min, followed by questions. The presentation will be open to the public; committee deliberations following the presentations will be restricted to the committee members only.

The result of the examination is determined by the Examination Committee based on the review of the written paper, oral examination, and feedback from the current or potential PhD thesis adviser.

A student is allowed to repeat the qualifying examination only once.

Formation of Dissertation Committee

Within three months of passing the qualifying examination, doctoral students must form a dissertation committee. The department provides a special form. The signed form must be submitted for the approval of the Associate Chair for Graduate Studies in Chemical Engineering. The committee must consist of the doctoral student's dissertation advisor, three additional faculty members from the department, and one member from outside the department (preferably outside the university). The committee may consist of more than five persons, subject to the approval of the Associate Chair. Once formed, the committee cannot change unless there is a written explanation and request from the doctoral student and/or his/her advisor. The Associate Chair for Graduate Studies handles such requests.

Research Proposal

Within six months of forming the dissertation committee (i.e., no more than nine months after passing the qualifying examination), doctoral students must make an oral presentation to their dissertation committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months. This ensures meeting the requirements that doctoral students must have an approved dissertation committee and an approved dissertation proposal within a year of passing the qualifying examination. The approved and signed proposal must be submitted to the Associate Chair for Graduate Studies so that it is kept in the student's file.

Dissertation Defense

An oral defense of the dissertation is required after submission of the final document to the dissertation committee for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted. The oral defense is open to the university community and general public and must be announced early.

Ph.D. in Materials Science and Engineering

The program is offered in two options, the Materials Science option **(**http://catalog.njit.edu/archive/2019-2020/graduate/science-liberal-arts/physics/materials-science-engineering-phd/**) and the** Materials Engineering option **(**http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-phd/**). These options are administered by the CSLA (College of Science and Liberal Arts) and NCE (Newark College of Engineering) colleges, respectively. A joint committee involving CSLA and NCE faculty will be in charge of overseeing this program.**

Materials Engineering Option

Administered by Department of Chemical and Materials Engineering (CME), NCE

Degree Requirements

Ph.D. coursework requirements

Ph.D. students with a recognized Master's degree or equivalent in materials engineering or a related field are required to take four 700-level 3-credit courses (12 credits).

Ph.D. students with a recognized Baccalaureate degree in materials engineering or a related field are required to take eight 600-level or 700-level 3-credit courses (24 credits) of coursework beyond the Baccalaureate degree as well as four additional 700-level 3-credit courses (12 credits), for a total of twelve 3-credit courses (36 credits).

Master's project (course 700), Master's thesis (course 701), or more than two independent study courses (courses 725 and 726) cannot be used to satisfy these coursework requirements.

A Ph.D. student may substitute a 600-level course for a 700-level course only after the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may request the student to take additional courses.

In addition to the minimum degree credits specified above, students must register every semester for ChE791, Graduate Seminar. Part-time students may request that this requirement be waived.

Dissertation advisor and committee

Students must select a dissertation topic and advisor within 6 months of joining the program. Before making a decision, students are encouraged to discuss research topics with several active research faculty members of the department.

The doctoral dissertation committee is led by the Dissertation Advisor. It must include at least five members, including at least four members of the department faculty and at least one external member.

Qualifying examination

All PhD candidates must pass a qualifying examination. Students must take the examination by the end of the second semester after enrolling in the PhD program. If repeated examination is necessary, the examination must be passed by the end of the third semester after enrolling in the PhD program.

<u>Pre-requisites for the qualifying examination:</u>

- Average grade of 3.5 for all four core courses and a minimum grade B in each of the core courses taken at NJIT

- Equivalent grade for the same subject course based on the MS transcript from an institution other than NJIT may be acceptable, as decided by the Graduate Studies Committee

- Students whose subject courses differ from those offered at NJIT, so that their MS transcript grades are not deemed acceptable as equivalent to the NJIT core courses by the Graduate Studies Committee are required to take final examinations for each of the core courses during their first two semesters after enrolling into PhD program to satisfy the present requirement.

- A student can take the final examination in each core course up to two times to satisfy the present requirement.

- Failing the present requirement is equivalent to the failing the qualifying examination.

<u>Qualifying examination format</u>

The examination is administered by an Examination Committee including at least three members of the CME graduate faculty. The Examination Committee is appointed by the Graduate Studies Committee each semester. The Examination Committee does not include the student's current or potential PhD thesis adviser.

Three months before the examination date, an assignment is given to a student to prepare for the qualifying examination. The assignment is given by the student's current or potential PhD thesis adviser in coordination with Examination Committee. The assignment identifies a research topic to be addressed in two parts of the examination:

- A written paper, comprising a literature review (no longer than 20 pages excluding references; 12 pts font, double spaced) on the identified research topic. The review needs to

• Identify an open research problem,
• Outline state of the art, and
• Propose an approach for future research in this area.
• If pertinent, results of preliminary work may be included.

- An oral presentation no longer than 20 min, followed by questions. The presentation will be open to the public; committee deliberations following the presentations will be restricted to the committee members only.

The result of the examination is determined by the Examination Committee based on the review of the written paper, oral examination, and feedback from the current or potential PhD thesis adviser.

A student is allowed to repeat the qualifying examination only once.

Ph.D. dissertation registration requirements

• Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of doctoral research (790B) per semester until they defend successfully the dissertation proposal.

• Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (790A) each semester until they complete all degree requirements.

• Students may take courses simultaneously with the 790 or 792 courses as per Ph.D. program guidelines or dissertation committee recommendation.

• With the exceptions approved by the Graduate Studies Committee, full-time students who do not meet the following deadlines will be dismissed from the Ph.D. program.

- The required coursework for the Ph.D. program and the (major part of the) QE must be completed successfully by the end of the second year in the program.
- The dissertation proposal must be defended successfully either by the end of the third year in the Ph.D. program or four semesters after registering for the first time in the 792 pre-doctoral research course, whichever occurs earlier.

The dissertation must be defended successfully no later than by the end of the sixth year in the Ph.D. program.

Pharmaceutical Management

Students will understand the role of the pharmaceutical industry in the global market and its implications; learn the fundamentals of the drug development cycle and the investment required to bring a drug to market, and learn the most important drug manufacturing processes and the key elements of dosage formulation. Special emphasis is placed on the project, quality, and financial management aspects of the pharmaceutical business.

Who is suited for this program?

The interdisciplinary Certificate in Pharmaceutical Management is designed to provide the students with an overview of the pharmaceutical industry, including information about drug discovery and development, FDA requirements, approval processes and the methodologies used by industry to comply with these regulations, drug dosage forms, and the role of key operational units in drug manufacturing processes.

What are the Required Courses?

Code	Title	Credits
Common Course		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
Electives		
Select two of the following:		6
EM 636	Project Management	
EM 637	Project Control	
IE 673	Total Quality Management	
PHEN 605	Pharmaceutical Packaging Technology	
PHEN 698	Special Topics in Pharmaceutical Engineering I	

What will I learn?

- Principles of Pharmaceutical Engineering : Overview of the pharmaceutical industry
- Validation and Regulatory Issues in the Pharmaceutical Industry with Information about drug discovery and development, FDA regulations, approval process and methodologies used by industry to comply with these regulations, drug dose forms, and the role of key operational units in drug manufacturing processes
- Competing in Global Markets : The role of the pharmaceutical industry in the global market and its implications
- Financial Management, Project Management, Project Control, Total Quality Management: These elective overview project, quality, and financial management aspects of the pharmaceutical business

Why study Pharmaceutical Management at NJIT?

NJIT recognizes pharmaceutical leaders' need for strong management to sustain the creation, storage and maintenance of databases of biological information in order to support drug discovery development.

Prerequisites

An undergraduate degree in a science or engineering field, with an undergraduate cumulative grade point average (GPA) of at least 2.8 on a 4.0 scale is usually required. Applicants with: (1) a science degree, (2) an engineering degree in a discipline other than chemical or mechanical engineering, or (3) a GPA below 3.0 but at least 2.8, may be conditionally admitted to the program. Conditions may involve completion of a bridge program designed on a case-by-case basis.

Related Degree Programs

All credits for the Pharmaceutical Management graduate certificate can be applied in its entirety to the NJIT MS in Pharmaceutical Systems Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/pharmaceutical-systems-management-ms/) and MS in Pharmaceutical Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/pharmaceutical-management-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Piero Armenante (http://directory.njit.edu/PersDetails.aspx?persid=armenant)

Pharmaceutical Manufacturing

NJIT recognizes the need of pharmaceutical leaders for the latest information on state-of-the-art technologies to support pharmaceutical process development and the operation of manufacturing processes at pharmaceutical companies. The Certificate in Pharmaceutical Manufacturing is designed to educate professionals with backgrounds in engineering or science and provide them with the critical skills required to work in pharmaceutical production and pharmaceutical manufacturing areas.

Who is suited for this program?

This Certificate is intended for students/professionals with a science (e.g., chemistry, pharmacy) or engineering background who intend to learn/expand their technical pharmaceutical manufacturing skills, and apply them to advance in their profession and within their companies.

What are the Required Courses?

Code	Title	Credits
Core Courses		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 602	Pharmaceutical Facility Design	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 605	Pharmaceutical Packaging Technology	3

What will I learn?

- Principles of Pharmaceutical Engineering: basic information about drug discovery and development, FDA requirements and approval processes, drug dosage forms, and the role of key operational units in drug manufacturing processes.
- Pharmaceutical Facility Design: instruction in design of state-of-the art pharmaceutical facilities for both manufacturing and R&D, by identifying key functional requirements and design concepts necessary to pharmaceutical processes. Interdisciplinary training will be provided in appropriate areas of facility design.
- Validation and Regulatory Issues in the Pharmaceutical Industry: development of a working knowledge of the Federal Code of Regulations and its impact on the pharmaceutical and allied industries.
- Pharmaceutical Packaging Technology: developing a working knowledge of the machinery and unit operations used in transferring a drug substance in the bulk final form to a finished product ready for sale to the consuming public.

Why Study Pharmaceutical Manufacturing at NJIT?

The Graduate Certificate in Pharmaceutical Manufacturing has been designed so that students are first provided with an overview of the pharmaceutical industry, including the fundamentals of the drug development cycle, FDA requirements, drug dosage forms, approval processes, and the methodologies used by industry to comply with these regulations. Additional courses then focus on the specifics of validation and regulations affecting the pharmaceutical and allied industries, as well as the more technical aspects of facility design. Examples of these are building and zoning codes; sterile/

aseptic processing; clean rooms and controlled environments; HVAC systems; and pharmaceutical water and clean steam systems. This unique combination of detail and overview is very hard to come by across the United States.

Prerequisites

An undergraduate degree with a science or engineering background, with an undergraduate cumulative grade point average (GPA) of at least 2.8 on a 4.0 scale is usually required. Applicants with: (1) a science degree, (2) an engineering degree in a discipline other than chemical or mechanical engineering, or (3) a GPA below 3.0 but at least 2.8, may be conditionally admitted to the program. Conditions may involve completion of a bridge program designed on a case-by-case basis.

Related Degree Programs

All credits for the Pharmaceutical Manufacturing Graduate Certificate can be applied in its entirety to the NJIT MS in Pharmaceutical Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/pharmaceutical-manufacturing-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Piero Armenante (http://directory.njit.edu/PersDetails.aspx?persid=armenant)

Pharmaceutical Technology

Who is suited for this program?

The Certificate in Pharmaceutical Technology is designed to educate professionals and provide them with the skills required to work in the pharmaceutical field, with particular emphasis on the engineering aspects of drug manufacturing, pharmaceutical production, pharmaceutical development, and pharmaceutical operations. The students will not only be provided with an overview of the pharmaceutical industry, including information about drug discovery and development, FDA requirements, approval processes and the methodologies used by industry to comply with these regulations, drug dosage forms, and the role of key operational units in drug manufacturing processes, but they will also be presented with the fundamentals of the drug development cycle and the unit operations typically associated with drug manufacturing, including their quantitative and design aspects.

What are the Required Courses?

Code	Title	Credits
Core Courses		
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 603	Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
PHEN 606	Pharmaceutical Unit Operations: Solids Processing	3

What will I learn?

- Principles of Pharmaceutical Engineering : Overview of the pharmaceutical industry.
- Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems which primarily examines engineering aspects of the pharmaceutical processes.
- Validation and Regulatory Issues in the Pharmaceutical Industry with Information about drug discovery and development, FDA regulations, approval process and methodologies used by industry to comply with these regulations, drug dose forms, and the role of key operational units in drug manufacturing processes.
- Pharmaceutical Unit Operations: Solids Processing which examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving solids processing.

Why Study Pharmaceutical Technology at NJIT?

The graduate certificate’s narrow focus allows you to dig deep into this specific topic, and start applying your knowledge sooner. You’ll learn from NJIT’s distinguished professors and instructors. The Certificate in Pharmaceutical Technology yields a stand-alone credential, which is a milestone in its own right, and it is also a springboard to the PhEn Master’s degree.

Prerequisites

An undergraduate degree in chemical engineering or mechanical engineering, with an undergraduate cumulative grade point average (GPA) of at least 3.0 on a 4.0 scale is usually required. Applicants with: (1) a science degree, (2) an engineering degree in a discipline other than chemical or mechanical engineering, or (3) a GPA below 3.0 but at least 2.8, may be conditionally admitted to the program. Conditions may involve completion of a bridge program designed on a case-by-case basis.

Both the Pharmaceutical Technology Graduate Certificate and the Pharmaceutical Engineering MS program have been designed so that people with different backgrounds can be admitted to the program. Nevertheless the programs are strongly oriented toward the ENGINEERING component of "Pharmaceutical Engineering". In addition, since the pharmaceutical industry is a chemistry-based industry a chemical engineering background is the most appropriate to enter the program. This implies that applicants who have a science background (e.g., a chemistry or pharmacy B.S. degree) or an engineering degree in a discipline other than chemical engineering will have to take a bridge program. This bridge program consists of three 3-credit courses (PhEn500, PhEn501 and PhEn502) specifically designed to provide non-chemical engineers with the necessary prerequisites to enter the program. These bridge courses cover a variety of topics, such as differential equations, statistics and business math (PhEn500), mass balances, thermodynamics, and chemical kinetics (PhEn501), and fluid flow, heat transfer and mass transfer (PhEn502). These courses do not count toward degree credit. Some regular PhEn courses (e.g., PhEn601 and PhEn604) can be taken concurrently with the bridge program courses.

Related Degree Programs

All credits for the Pharmaceutical Technology Certificate can be applied in its entirety to the NJIT MS in Pharmaceutical Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/chemical-biological-pharmaceutical/pharmaceutical-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/pharmaceutical-technology-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Piero Armenante (http://directory.njit.edu/PersDetails.aspx?persid=armenant)

POLYMERS AND PLASTICS

From the NJIT Department of Chemicals and Materials Engineering, the Graduate Certificate in Polymers and Plastics prepares students to apply mathematical and scientific principles to the design, development and operational evaluation of synthesized macromolecular compounds and their application to specific engineering uses. This includes the development of industrial materials with tailored properties, the design of lightweight structural components, the use of liquid or solid polymers, and the analysis and control of polymerization processes.

Who would be suited to take this program?

This program is designed with Chemical Engineers in mind. Example industries where occupations may exist in this area may include: agriculture, automotive, fast-moving consumer goods (FMCG), consumer packaged goods (CMG), or chemical production management.

What are the Required Courses?

Code	Title	Credits
Core Courses		**12**
Select four (4) of the following:		
CHE 681 (http://catalog.njit.edu/archive/2019-2020/search/?P=CHE 681)	Polymerization-Principles and Practice	
ME 678 (http://catalog.njit.edu/archive/2019-2020/search/?P=ME 678)	Engineering Design of Plastic Products	
MTSE 610 (http://catalog.njit.edu/archive/2019-2020/search/?P=MTSE 610)	Mechanical Properties of Materials	
CHE 682 (http://catalog.njit.edu/archive/2019-2020/search/?P=CHE 682)	Polymer Structures and Properties	
MNE 654 (http://catalog.njit.edu/archive/2019-2020/search/?P=MNE 654)	Design for Manufacturability	
MTEN 613 (http://catalog.njit.edu/archive/2019-2020/search/?P=MTEN 613)	Characterization of Materials	

What will I learn?

- ***Polymerization-Principles and Practice* -** The structural and synthetic aspects of polymers and examines in detail a number of bench and industrial scale polymerization methods. In addition to kinetics and mechanisms of commercially important polymerization systems, students will examine reactive modification of synthetic and natural polymers and provides an introduction to applicable characterization methods.
- ***Engineering Design of Plastic Products* -** Structure and properties of plastics including stress-strain behavior and the effect of fillers and reinforcements. Designing for impact, flexure, shear, friction, puncture, creep and fatigue. Case studies of structural, electrical, and optical applications.
- ***Mechanical Properties of Materials* -** Elements of elasticity and plasticity theory, deformation and fracture behavior of materials, the concept of dislocations and their interaction with other lattice defects, strengthening mechanisms in solids, and principles of failure analysis. Materials to be studied include metals, polymers, ceramics, glasses, and composites.
- ***Polymer Structures and Properties* -** Polymer structures and properties and their relationships from the molecular viewpoint to phenomenological descriptions. Topics include thermodynamics of a single molecule, dynamic theory and viscoelasticity of polymers, polymer solids and mechanical properties, rubbers, polymer blends and composites, biological polymers, and special applications.
- ***Design for Manufacturability* -** Methodologies used in the synthesis and analysis of product design to optimize manufacturability. The relationship of design to production processes, product material, material handling, quality costs, and CAD/CAM are presented. Emphasis is on both formed products and assembled products. Simulation and other design analysis tools are employed.
- ***Characterization of Materials* -** Introduction in chemical and materials engineering, and other engineering and science disciplines, to fundamentals and theory of different types of materials characterization tools. Methods and techniques necessary to understand and quantify diverse materials properties will be discussed. As important for many methods, basic principles of interaction of radiation and particle beams with matter will be studied. Topics include, but are not limited to: Diffraction methods; imaging via optical, scanning, transmission electron, scanning tunnelling, and field ion microscopy; microanalysis and spectroscopy, including energy dispersive, wavelength dispersive, Auger methods; secondary ion mass spectroscopy, X-ray photoelectron spectroscopy; materials preparation for analysis, including electron, ion growth, sputtering; thermal analysis: DTA, DSC; and depending on the availability and functionality of equipment, lab visits and demonstrations will be scheduled to the class to discuss some case studies.

Why study Polymers and Plastics at NJIT?

One of the oldest departments of Newark College of Engineering, the Otto H. York Department of Chemical and Materials Engineering awarded its first three baccalaureate degrees in 1923. This program is interdisciplinary by nature, with learn outcomes crossing both the science and the engineering materials and chemicals realms, yet more lean toward the engineering side. Chemical engineers use chemistry, biology, physics and math in an integrated engineering mode in order to manufacture materials and products to modern society. They are involved with the full scale of processes, from the laboratory bench to the pilot plant and eventually to the manufacturing facility.

Into what industries might holders of this program find employment?

- Agriculture
- Automotive
- Fast-Moving Consumer Goods (FCMG)
- Consumer Packaged Goods (CMG)
- Chemical Production Management

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (chemical engineering, manufacturing engineering, materials science, materials engineering, etc.).

Related Degree Programs

This graduate certificate may transition into a NJIT MS in Materials Science and Engineering: Materials Engineering option (https://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-ms/).

Faculty Advisor: Ed Dreyzin (https://chemicaleng.njit.edu/faculty/dreyzin/)

Civil and Environmental Engineering

Civil Engineering

In the information technology age, more resources are available for building new cities, repairing the infrastructure, cleaning up the environment: these are all tasks for the civil engineer. Major corporations, government agencies, private consulting and construction firms, and universities are just some of the organizations that employ civil engineers.

In-depth knowledge in one of the areas of civil engineering is essential for professional practice as well as for research. Courses are taught by full-time faculty members with a range of academic and professional experience as well as by adjunct instructors who are experts in their fields. Those students interested in research at the master's level or continuing their education at the doctoral level should consider working with faculty involved in one of the university's related research centers.

Master of Science in Civil Engineering

The M.S. in Civil Engineering is designed for those who want both specialized course work and the flexibility to tailor their program to their needs.

Admission Requirements

Applicants are expected to have an undergraduate degree in civil engineering or its equivalent, and must have proficiency in basic sciences and mathematics. Students who lack an appropriate undergraduate background may be granted conditional admission in order to complete a bridge program or its equivalent. These courses are taken in addition to regular degree requirements; descriptions may be found in the undergraduate catalog. A minimum bachelor's GPA of 2.8 on a 4.0 scale, or equivalent, is normally required for admission. The Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) is required for all international applicants. The Graduate Record Examination (GRE) is required for international applicants and full-time domestic applicants.

Graduate Certificate Program

A 12-credit graduate certificate in Construction Management is available as a step toward this degree. Please see **Graduate Certificates** in this catalog for further information. For more information about continuing and distance education, please contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; email: cpe@njit.edu.

Master of Architecture (M.Arch.) and M.S. in Civil Engineering Dual Degree Program

This program permits students to obtain a Master of Architecture with a Master of Science in Civil Engineering. There is no reduction in the degree requirements for the Master of Architecture program. This dual degree program permits students to obtain the M.S. in Civil Engineering in substantially less time; in some cases, in only one more semester of full-time study. This dual degree program is described in the Architecture degree program section (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-civil-engineering-ms/) in this catalog.

Civil Engineering - Online Master of Science in Civil Engineering

Online learning allows students the chance to earn a master’s degree without coming to campus. Online courses are virtual learning communities with instructor-led online classrooms that use rich platforms to present course material. There are three specialty areas to choose from: Construction Management, Structural Design and Construction and Transportation.

Admission Requirements

Students are expected to have an undergraduate degree in engineering or its equivalent.

PhD in Civil Engineering

This is a program for superior students with master's degrees in civil engineering or allied fields who wish to do advanced research in an area of civil engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in civil engineering may be accepted directly into the doctoral program.

Admission Requirements

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. The GRE (general section) is required of all applicants. The Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) is required for international applicants.

M.S. in Critical Infrastructure Systems Admission Requirements

Students are expected to have an undergraduate degree in engineering or its equivalent.

Bridge program-Students who lack an appropriate background are asked to make up deficiencies by taking a program of courses that is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements, and typically center around upgrading their background in statistics and mathematics. If this background is not sufficient, the minimal bridge course consists of EM 503 Methods and Applications of Industrial Statistics and Probability.

Environmental Engineering

Environmental engineers are essential participants in the planning, design and construction of waste water and potable water treatment plants, solid waste disposal systems, site remediation and emission control measures, and other similar projects. Major corporations, government agencies, private consulting and construction firms, and universities are just some of the organizations that employ environmental engineers.

In-depth knowledge in environmental engineering is essential for professional practice as well as for research. Full-time faculty members with a range of academic and professional practice experience as well as by adjunct instructors who are experts in their field teach the courses. Those students interested in research at the master's level or continuing their education at the doctoral level should consider working with faculty involved in one of the university's related major research centers.

Master of Science in Environmental Engineering

The M.S. in Environmental Engineering is designed for those who want both specialized course work and the flexibility to tailor their program to their needs.

Admission Requirements

Applicants are expected to have an undergraduate degree in engineering or its equivalent. Students who lack an appropriate undergraduate background may be granted conditional admission in order to complete a bridge program or its equivalent. These courses are taken in addition to regular degree requirements; descriptions may be found in the undergraduate catalog. A minimum bachelor's GPA of 2.8 on a 4.0 scale, or equivalent, is normally required for admission. The Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) is required for all international applicants. The Graduate Record Examination (GRE) is required for international applicants and full-time domestic applicants.

Doctor of Philosophy in Environmental Engineering

This is a program for superior students with master's degrees in environmental engineering, civil engineering, or allied fields who wish to conduct advanced research in an area of environmental engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in civil engineering or environmental engineering may be accepted directly into the doctoral program.

Admission Requirements

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. The GRE (general section) is required of all applicants. The Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) is required for international applicants.

Transportation

NJIT's transportation program prepares students to be transportation planners, engineers, and managers who can plan, design, operate, and manage transportation systems capable of satisfying society's transportation needs.

Transportation is vital to our society's proper functioning, providing mobility of people, goods and services. It enables people to access job markets and participate in recreational, cultural, educational, and social activities. It adds value to products by moving them to their destination in time for their use. The transportation field also is a major contributor to the economy, as a consumer of resources and as a supplier of jobs.

Transportation functions in a very complex environment which, at the beginning of the 21st Century, is characterized by constant change in the technological, regulatory and legal frameworks. Transportation professionals must not only be able to meet the technological challenges of new systems, they must also be capable of fitting these systems into the social, economic, and physical environments in a manner that improves the quality of life for all.

Through the NJIT-based Institute for Transportation, the transportation graduate program provides excellent opportunities for students to engage in research on all forms of transportation, including all phases of activities concerned with the provision of services and the movement of people and goods. The Institute for Transportation is a major resource for public and private organizations and is well-known for its academic programs and research activities.

Master of Science in Transportation

This is a program for students from diverse educational backgrounds with a variety of career goals that prepares them for careers in designing, planning, operating, maintaining and managing urban and rural transportation systems. The master's degree is a valued professional credential for individuals engaged in the transportation field.

Graduate Certificate Program

A 12-credit graduate certificate in Transportation Studies is available as a step toward this degree. Please see **Graduate Certificates** in this catalog for further information. For more information about continuing and distance education, please contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; email: cpe@njit.edu.

Off-Campus Programs: At the New Jersey Department of Transportation (NJ DOT), in Trenton, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty.

Admission Requirements

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in economics, mathematics, probability and statistics, and computers.

Doctor of Philosophy in Transportation

The doctoral program is for well-qualified students who are mature in scholarship and purpose. It offers a well-balanced mixture of theoretical studies and experimental research. A student must demonstrate creative thinking, self-motivation, and ability to do independent research. In their research, students are expected to deal with complex issues, effectively formulate difficult problems, devise new methodology, and achieve new and exceptional results.

Admission Requirements

Students should have adequate preparation in mathematical and other analytical techniques, and substantial knowledge of the ideas and techniques of synthesis. A thorough understanding of the social and economic factors intrinsic to the functioning and development of transport in urban areas also is necessary. It is expected that students will have earned a minimum GPA of 3.5 in a master's degree program in engineering, planning, or business administration from an accredited university. Outstanding students with baccalaureate degrees also may be accepted. All applicants must take the GRE. Full-time study is preferred for doctoral studies.

NJIT Faculty

A

Adams, Matthew, Assistant Professor

Axe, Lisa B., Professor, Chemical Engineering (Joint Faculty)

B

Bagheri, Sima, Professor

Bandelt, Matthew, Assistant Professor

Boufadel, Michel, Professor

C

Chien, I Jy, Steven, Professor

D

Daniel, Janice R., Associate Professor

Dauenheimer, Edward G., Professor Emeritus

Ding, Yuan, Associate Professor

Dresnack, Robert, Professor Emeritus

E

Esmaili, Danial, University Lecturer

G

Goncalves da Silva, Bruno, Assistant Professor

Greenfeld, Joshua S., Professor Emeritus

H

Hsieh, Hsin-Neng, Professor

K

Karaa, Fadi A., Associate Professor

Khera, Raj P., Professor Emeritus

Konon, Walter, Professor

L

Lee, Joyoung, Assistant Professor

Liu, Rongfang, Professor

M

Mahgoub, Mohamed, Associate Professor, Engineering Technology (Joint Faculty)

Marhaba, Taha F., Professor

Meegoda, Jay N, Professor

Milano, Geraldine, Senior University Lecturer

O

Olenik, Thomas J., Associate Professor

P

Potts, Laramie, Associate Professor, Engineering Technology (Joint Faculty)

R

Raghu, Dorairaja, Professor Emeritus

S

Saadeghvaziri, Mohamad A., Professor

Saigal, Sunil, Distinguished Professor

Salek, Franklin, Professor Emeritus

Santos, Stephanie R, University Lecturer

Schuring, John, R., Professor Emeritus

Spasovic, Lazar, Professor

W

Washington, David, Associate Professor, Engineering Technology (Joint Faculty)

Wecharatana, Methi, Professor

Z

Zhang, Wen, Associate Professor

Programs

- Civil Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/)
- Civil Engineering - M.S. online (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms-online/)
- Critical Infrastructure Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/critical-infrastructure-systems-ms/)
- Environmental Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-ms/)
- Transportation - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-ms/)

Double Majors **(**http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/special-programs/**)**

- Architecture - M.Arch. and Civil Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/architecture-design/architecture/march-civil-engineering-ms/)

Programs

- Civil Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-phd/)
- Environmental Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-phd/)
- Transportation - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-phd/)

Programs

- Construction Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/construction-management-cert/)
- Environmental Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-engineering-studies-cert/)
- Environmental Science and Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/environmental-science-engineering-cert/)
- Hydrology and Water Resources Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/hydrology-and-water-resources-engineering-cert/)
- Intelligent Transportation Systems (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/intelligent-transportation-systems-cert/)
- Transportation Studies (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-studies-cert/)

Civil and Environmental Engineering Courses

CE 501. Introduction to Soil Behavior. 3 credits, 4 contact hours.
Prerequisites: MECH 320, MECH 235 with a grade of C or better and MECH 236 with a grade of C or better(see undergraduate catalog for descriptions). Open only to the students in bridge program. Permission from CEE department graduate advisor is required. Covers the necessary concepts in strength of materials, geology and soil mechanics required for the bridge program in M.S. in Environmental Engineering and Geoenvironmental Engineering option.

CE 502. Civil Construction Methods. 3 credits, 3 contact hours.
Prerequisites: PHYS 111 and MATH 112, or equivalents Open only to students in Online M.S. in Civil Engineering, Construction Management Option. Covers essential concepts in civil and construction engineering including site surveys, construction materials, and soil behavior to partially satisfy bridge requirements.

CE 506. Remote Sensing of Environment. 3 credits, 3 contact hours.
Prerequisite: PHYS 234 (see undergraduate catalog for description). Covers the principles of remote sensing, general concepts, data acquisition procedures, data analysis and role of remote sensing in terrain investigations for civil engineering practices. Data collection from airborne and satellite platforms will be emphasized. Photographic and non-photographic sensing methodologies will be covered as well as manual and computer assisted data analysis techniques for site investigations and examination of ground conditions.

CE 531. Design of Masonry and Timber Structures. 3 credits, 3 contact hours.
Prerequisite: CE 332 (see undergraduate catalog for description). Study of basic properties of clay and concrete masonry units and wood. The masonry segment includes discussion of unreinforced bearing walls subjected to concentric as well as eccentric loads. Lateral-force resistance of unreinforced and reinforced masonry systems are introduced and new developments to strengthen and retrofit unreinforced masonry walls are discussed. The timber design portion includes design and behavior of wood fasteners, beams, columns, and beam-columns as well as introduction to plywood and glued laminated members.

CE 552. Geometric Design of Transportation Facilities. 3 credits, 3 contact hours.
Prerequisite: CE 350 or equivalent (see undergraduate catalog for description). Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. Same as TRAN 552.

CE 553. Design and Construction of Asphalt Pavements. 3 credits, 3 contact hours.
Importance of designing proper asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. Same as TRAN 553.

CE 590. Grad Coop Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from the civil engineering department and the Division of Career Development Services. Cooperative education/internship providing on-the-job reinforcement of academic programs in civil engineering. Work assignments and projects are developed by the co-op office in consultation with the civil engineering department; and evaluated by civil engineering faculty co-op advisors.

CE 591. Grad Coop Work Experience II. 1 credit, 1 contact hour.
Restriction: permission from the civil engineering department and the Division of Career Development Services.

CE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: permission from the civil engineering department and the Division of Career Development Services.

CE 593. Graduate Co-Op Work Exp IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CE 602. Geographic Information System. 3 credits, 3 contact hours.
Restriction: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control. Introduces this emerging technology and its applications. Same as MIP 652 and Tran 602.

CE 605. Research Methods in Remote Sensing. 3 credits, 3 contact hours.
Prerequisites: CE 601 and MATH 661. Major components of RS data acquisition systems, overview of image processing techniques with emphasis on neural network and traditional pattern recognition, principal component transformations, and data reduction. Emphasizes geometric and mapping aspects of RS/GIS techniques for linking RS images with spatial data, sources of error, and accuracy assessment techniques. Hands-on experience with existing hardware/software (ERDAS & GENESIS).

CE 606. Geospatial Data Applications. 3 credits, 3 contact hours.
Prerequisite: CE 602. The course focuses on geospatial data processing, information extraction and analysis tools. It provides visualization and decision support applications using desktop GIS software. Examples of the student projects include: Applications of integrated geospatial date in environmental, infrastructure, urban planning and homeland security.

CE 610. Construction Management. 3 credits, 3 contact hours.
Restriction: B.S. degree in CE, technology, architecture, or related field. Managerial aspects of contracting. Study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning.

CE 611. Project Planning and Control. 3 credits, 3 contact hours.
Prerequisite: CE 610. Management tools as related to construction projects are analyzed and applied to individual projects. Emphasis is on network scheduling techniques, time-cost analysis, resource allocation and leveling, cost estimating, bidding strategy, and risk analysis.

CE 614. Underground Construction. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in soil mechanics. Various aspects of underground construction, including rock and soft ground tunneling; open cut construction; underpinning; control of water; drilling and blasting rock; instrumentation; and estimating underground construction costs. Case studies and a field trip to an underground construction site will be included.

CE 615. Infrastructure and Facilities Remediation. 3 credits, 3 contact hours.
Restriction: graduate standing in civil engineering and basic knowledge of structures, and material science. Examines the methodology of inspection, field testing, evaluation and remediation of existing infrastructure and facilities, which include pipelines, tunnels, bridges, roadways, dams, and buildings. Typical materials distress and failure scenarios will be covered with remediation options through the use of case studies.

CE 616. Construction Cost Estimating. 3 credits, 3 contact hours.
Prerequisite: CE 610. Full range of construction cost-estimating methods including final bid estimates for domestic building and heavy/highway projects; computerized takeoff and estimating techniques; international construction; financial and cost reporting; databases; indices; risk; competition; performance; and profit factors.

CE 617. Historic Preservation. 3 credits, 3 contact hours.
This course addresses the many aspects of structural preservation from both an engineering and aesthetic perspective. Course topics include: permits and regulations, an overview of architectural styles, designation of historic structures, past methods of construction, current methods of preservation and the availability of grants and funding. Knowledge gained from the course will be applied directly to course projects involving the evaluation and recommendations needed for the proposed preservation of an existing structure.

CE 618. Applied Hydrogeology. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in earth science/geology, fluid mechanics, and calculus or permission of instructor. Examines ground water and contaminant movement through the subsurface environment. A basic understanding of the aquifer geology is emphasized. Hydrogeologic applications including well design, pumping tests, and computer modeling of subsurface flow, and methods to monitor and remediate contaminated groundwater are introduced.

CE 620. Open Channel Flow. 3 credits, 3 contact hours.
Prerequisite: undergraduate fluid mechanics. The principles developed in fluid mechanics are applied to flow in open channels. Steady and unsteady flow, channel controls, and transitions are considered. Application is made to natural rivers and estuaries.

CE 621. Hydrology. 3 credits, 3 contact hours.
Prerequisite: undergraduate fluid mechanics. The statistical nature of precipitation and runoff data is considered with emphasis on floods and droughts. The flow of groundwater is analyzed for various aquifers and conditions. Flood routing, watershed yield, and drainage problems are considered.

CE 622. Coastal Engineering. 3 credits, 3 contact hours.
Prerequisite: fluid mechanics and calculus. An introductory course covering basic wave theory, sediment transport and ocean circulation. The application of these principles to various coastal engineering problems will be discussed, including beach erosion, pollution transport in coastal waters, and the design of shore protection structures.

CE 623. Groundwater Hydrology. 3 credits, 3 contact hours.
Prerequisites: undergraduate fluid mechanics and computer programming, or consent of instructor. Basic principles of groundwater hydraulics; Darcian analysis of various aquifer systems; unsaturated flow into porous mediums; transport of contaminants in soil media; and mathematical models for fluid and contaminant transport.

CE 630. Matrix Analysis of Structures. 3 credits, 3 contact hours.
A review of matrix operations and energy methods, and development of flexibility and stiffness methods used in linear-elastic structural analysis. Behavior of continuous beams, plane trusses, space trusses, and frames are studied.

CE 631. Advanced Reinforced Concrete Design. 3 credits, 3 contact hours.
Prerequisites: an undergraduate course in theory and design of reinforced concrete. A review of basic concepts of elastic and ultimate strength theories and a study of the present design codes. Topics include: design of concrete building frames, two-way slabs, flat slabs, deep beams, and other structural elements using the above two theories.

CE 632. Prestressed Concrete Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate course in theory and design of reinforced concrete. Analysis and design of pre-tensioned and post-tensioned prestressed concrete elements for both determinate and indeterminate structures will be studied. Examples of prestressed elements used in buildings and bridges will be discussed, as well as the source and magnitude of prestress losses.

CE 634. Structural Dynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in structural analysis. Dynamic analysis of beams, frames, and other types of structures. Practical methods developed are applied to problems such as the analysis of the effects of earthquakes on buildings and moving loads on bridges.

CE 635. Fracture Mechanics of Engineering Materials. 3 credits, 3 contact hours.
Restriction: graduate standing in civil and/or mechanical engineering and basic knowledge of structures and mechanics of materials. Basic principles of fracture mechanics to increase understanding of cracking and fracture behavior of materials and structures. Emphasis on practical applications of fracture mechanics.

CE 636. Mechanics and Stability of Structures. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in theory of structural analysis. Topics include structural design concept; stability criteria; elastic and inelastic buckling; column buckling; lateral buckling of beams; stability of frames; stability of plates and shell; local buckling and post-buckling.

CE 637. Short Span Bridge Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in steel design and concrete design, and some knowledge of prestressed concrete fundamentals. Design and performance of highway and railroad bridges, particularly steel and prestressed concrete structures since they are most common in the northeast; and computer applications including bridge geometry, abutment design and composite beam design.

CE 638. Nondestructive Testing Methods in Civil Engineering. 3 credits, 3 contact hours.
Familiarizes the civil engineering student with nondestructive testing (NDT) techniques currently employed for evaluation and condition monitoring of civil structures and construction materials. Major emphasis in the application of NDT methodologies to steel, concrete, and timber as the construction material. Covers theories, principles, and testing methodologies associated with individual technologies from specific material point of view. Discusses advantages and limitations pertaining to the application of individual NDT technologies to construction materials.

CE 639. Applied Finite Element Methods. 3 credits, 3 contact hours.
Prerequisites: CE 332 and CS 101. Introduction to application of finite element method to problems of structural analysis and design. Review of matrix algebra and the stiffness method of structural analysis. Applications include trusses, frames, plates, shells, and problems of plane stress/strain. Application of finite element method to design.

CE 641. Engineering Properties of Soils. 3 credits, 3 contact hours.
Prerequisite: approved undergraduate course in soil mechanics within last five years. An in-depth study of physical and mechanical properties of soils. Topics include clay mineralogy, shear behavior and compressibility of fine and coarse grained soil; and in-situ measuring techniques such as vane shear, core penetration and pressure meter. Laboratory work includes consolidation test and triaxial test, with emphasis on analysis, interpretation and application of data to design problems.

CE 642. Foundation Engineering. 3 credits, 3 contact hours.
Prerequisites: approved undergraduate courses in soil mechanics and foundation engineering. The salient aspects of shallow foundation design such as bearing capacity and settlement analyses. Topics are relevant to the deep foundation, selection of the type and the determi-nation of load bearing capacity from soil properties, load tests, and driving characteristics utilizing wave equation analyses. Earth pressure theory and retaining wall design.

CE 643. Advanced Foundation Engineering. 3 credits, 3 contact hours.
Prerequisite: CE 642. Lateral and earth pressure computations for the design of retaining walls, bulkheads, cellular cofferdams, and sheetpiles. Also considers the design of internal bracing systems and anchors, soil nailing and reinforced earth. Slope stability of embankments and dams.

CE 644. Geology in Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate course in geology or permission of instructor. Geology has a significant influence on how we plan, design, and construct engineering works. This course examines how the geologic formations underlying a locale will ultimately determine land use, control structure design, and affect construction material availability. Included is a study of the various rock-forming processes and geologic agents that have shaped Earth's surface. The course also explores the role of geologic factors in assessing environmental impacts and natural hazards such as earthquakes, subsiding soils, and landslides. Case study applications and a field trip are included.

CE 645. Rock Mechanics. 3 credits, 3 contact hours.
Prerequisite: CE 342. Restriction: approved undergraduate course in soil mechanics within last five years or permission of instructor. Theoretical and experimental aspects of rock mechanics and rock engineering. Review of laboratory and field rock testing; empirical and analytical methods for describing strength, deformability and conductivity of intact rock and rock masses. Fracture mechanics and mechanics of discontinuous media, including flow through discontinuous media and hydraulic fracturing. Design and analysis of rock slopes, underground structures in rock and foundations on rock. Includes a term paper/design project.

CE 646. Geosynthetics & Soil Imp. 3 credits, 3 contact hours.
Prerequisite: CE 341 (see undergraduate catalog for description). Includes engineering properties of geosynthetics and their application in civil engineering, such as filtration, seepage, and erosion control; subgrade and slope stabilization. Soil improvement topics include preloading, electrokinetic stabilization, soil modification, admixtures and grouting.

CE 647. Geotechnical Aspects of Solid Waste. 3 credits, 3 contact hours.
Prerequisites: CE 341, CE 341A or equivalents (see undergraduate catalog for descriptions). Geotechnical aspects of solid waste such as municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems. Primary emphasis is on municipal wastes.

CE 648. Flow Through Soils. 3 credits, 3 contact hours.
Prerequisite: CE 641. Explains the fundamentals of fluid flow through saturated and unsaturated soils and the use of computer programs for the solution of boundary value fluid flow problems in soils. The first two-thirds of the course are devoted to flow through saturated soils. The topics are mathematical description of flow through soils, solutions for steady state and transient state fluid flow and geotechnical applications. The last one-third is devoted to flow through unsaturated soils. Topics include steady state of transient state fluid flow and a presentation of how these concepts are applied to geoenvironmental problems.

CE 649. Design & Construction of Concr. 3 credits, 3 contact hours.
Importance of designing concrete pavements to resist distress or failure. Topics include the stresses in Rigid Pavement, Traffic and Loading, Material Characterization, Drainage, Pavement Performance, Rigid Pavement Design and Overlay Design.

CE 659. Flexible and Rigid Pavements. 3 credits, 3 contact hours.
Prerequisite: CE 341 or equivalent (see undergraduate catalog for description). Types of rigid (Portland cement) and flexible (bituminous) pavements. Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. Same as TRAN 659.

CE 671. Performance and Risk Analysis of Infrastructure Systems. 3 credits, 3 contact hours.
This course presents a comprehensive systems approach to infrastructure asset management across areas of public and private infrastructure. Topics include the framework of integrated asset management illustrated in transportation, water and wastewater systems, the economic evaluation of infrastructure options, using life cycle cost analysis (LCCA) and cost-benefit analysis (CBA). The elements of performance measurement and modeling, including condition assessment and information management, failure and impact analysis are covered. Decision and risk analysis are covered to enable students to develop a holistic economic, performance and risk analysis approach to infrastructure management illustrated in a term project.

CE 672. Security Management of Critical Infrastructure. 3 credits, 3 contact hours.
This course focuses on the areas of vulnerability assessment and security management of critical infrastructure systems. A review of techniques for facility and network modeling and performance simulation, leads to sector-specific approaches to vulnerability analysis and critical infrastructure protection strategies using a Model-Based Vulnerability Analysis (MBVA). Covered critical infrastructure systems include water supply/environmental, transportation, power and energy systems, SCADA systems, cyber-infrastructure and telecommunications. The course ends with a review of the combined use of multi-criteria analysis techniques, expert heuristic response to scenarios and network analysis techniques in a general framework for vulnerability and security management of infrastructure systems in its key aspects: prevention, warning/detection and event mitigation and response planning and execution.

CE 700. Master's Project. 0 credits, 0 contact hours.
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of civil engineering problems not covered by regular graduate course work is required. A student with an exceptional project in CE 700 may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for CE 701 Master's Thesis. Students must register for 3 credits every semester until the project is completed.

CE 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering. A written report must be submitted to the project advisor. The student cannot register in CE 700B more than once and the incomplete (I) grade is not allowed.

CE 701. Masters Thesis. 0 credits, 0 contact hours.
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester until completion and submittal of an approved document. Credit will be limited, however, to the 6 credits indicated for the thesis.

CE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

CE 702. Special Topics in Civil Engineering. 3 credits, 3 contact hours.
Restriction: advisor's approval. Topics of special current interest in civil engineering.

CE 703. Concrete Durability. 3 credits, 3 contact hours.
Prerequisites: Undergraduate course in construction materials or reinforced concrete design, or permission of the instructor. This course will cover the design and maintenance of concrete structures and pavements from a material choice point of view. Students will learn how to design concrete mixtures, choose alternative and sustainable concrete materials, produce concrete specifications, protect concrete from long-term deterioration, and design solutions for repairing existing concrete. Students will learn about the mechanisms and chemistry and concrete deterioration. The following key topics will be covered: cement production, supplementary cementitious materials, mixture design and proportioning, concrete durability, dimensional stability, freeze-thaw attack, sulfate attack, corrosion, alkali-silica reaction, alternative cements, concrete specifications, and concrete construction.

CE 705. Mass Transportation Systems. 3 credits, 3 contact hours.
Prerequisites: CE 625 and TRAN 610 or IE 610. An investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. Same as TRAN 705.

CE 711. Methods Improvement in Construction. 3 credits, 3 contact hours.
Prerequisite: CE 610. Improved methods in construction; various techniques of work sampling and productivity measurement; and current innovations in the construction industry for increasing efficiency.

CE 720. Water Resource Systems. 3 credits, 3 contact hours.
Prerequisites: CE 620, CE 621. A system methodology is applied to the analysis of water resource development and operation. Topics include operational hydrology, water quality criteria, streamflow requirements, resource allocation, and economics. Mathematical models are developed and employed in the evaluation of a case study.

CE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

CE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for CE 726 if they have taken CE 725 in a prior semester.

CE 727. Independent Study III. 3 credits, 3 contact hours.
Restriction: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 730. Plastic Analysis and Design. 3 credits, 3 contact hours.
Prerequisite: CE 639. Theory of plasticity applied to structural design. Study of methods of predicting strength and deformation of single and multi-story steel frames in the plastic range. Comparison of plastic and prestressed concrete.

CE 733. Design of Metal Structures. 3 credits, 3 contact hours.
Prerequisites: CE 639 and CE 636. Methods of design of metal structural systems. Topics include combined action of unsymmetrical sections, torsion of open and closed sections, buckling of columns and plates with various end conditions, and design of curved and boxed girders.

CE 734. Design of Tall Buildings and Space Structures. 3 credits, 3 contact hours.
Prerequisites: CE 639 and CE 636. Design of tall buildings and space structures emphasizing framing systems, and recent developments and current research related to the design of such structures.

CE 736. Finite Element Methods in Structural and Continuum Mechanics. 3 credits, 3 contact hours.
Prerequisites: MECH 630 and CE 630. Restriction: a working knowledge of computer programming. Finite element approaches for analysis of plane stress problems, plates in flexure, shells, and three-dimensional solids; and choice of interpolation functions, convergence, and the capabilities of the methods.

CE 737. Earthquake Engineering. 3 credits, 3 contact hours.
Prerequisite: CE 634. Practical design solutions for resisting the damaging effects of earthquake ground motions and other severe dynamic excitations. Factors which control dynamic response in elastic and inelastic ranges, and the nature of severe dynamic excitations. Theories of structural analysis and dynamics, and modern design methodologies on the behavior of structures.

CE 739. Structural Optimization. 3 credits, 3 contact hours.
Prerequisite: CE 639. Application of methods of mathematical programming to problems of optimal structural design. Optimal criteria methods, discrete and continuous systems, and code design will be covered.

CE 742. Geotechnology of Earthquake Engineering. 3 credits, 3 contact hours.
Prerequisite: CE 641. Explains the fundamentals of propagation of the earthquakes through soils to supporting structures and the use of computer programs in the solution of boundary value problems in soils. The first half is devoted to synthesis of earthquakes, mathematical formulation of the problem, measurement of applicable soil parameters, use of computer programs to solve 1-D wave propagation problems in soils with structures. The second half is devoted to soil liquefaction, soil-structure interaction, and design of machine foundations.

CE 753. Airport Design and Planning. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or EM 693 and CE 660. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. Same as IE 753 and TRAN 753.

CE 765. Multi-modal Freight Transportation Systems Analysis. 3 credits, 3 contact hours.
Prerequisites: TRAN 610 or equivalent and CE 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. Same as EM 765 and TRAN 765.

CE 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached. Registration for additional credits may be permitted beyond the 6, with the approval of the advisor, to a maximum of 12 credits per semester. If the dissertation is not completed after 36 credits, registration for an additional 3 credits per semester is required thereafter. Registration for 3 credits is permitted during the summer session, hours to be arranged.

CE 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: CE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in CE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

CE 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CE 791. Since the CE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in civil engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

CE 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: CE 791. Since the CE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in civil engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

CE 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CE 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CE 790F. Doct Dissertation & Res. 15 credits, 3 contact hours.

CE 791. Graduate Seminar. 0 credits, 1 contact hour.
A seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for CE 790 unless requirement is waived, in writing, by the dean of graduate studies.

CE 792. Pre-Doctoral Dissertation. 3 credits, 3 contact hours.
Co-requisite: CE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in civil engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

CE 793B. Professional Project. 3 credits, 3 contact hours.

ENE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

ENE 630. Physical Processes of Env Syst. 3 credits, 3 contact hours.

ENE 660. Introduction to Solid and Hazardous Waste Problems. 3 credits, 3 contact hours.
Prerequisite: ENE 663. (May be taken concurrently.) Introduction to solid waste disposal. Industrial and urban sources of solid waste and conventional methods of waste disposal. Application of engineering principles related to these topics.

ENE 661. Environmental Microbiology. 3 credits, 3 contact hours.

ENE 662. Site Remediation. 3 credits, 3 contact hours.
Prerequisite: EM 631. Can be taken concurrently with EM 631. Examines site remediation from start to finish. Includes regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Examines established and innovative cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.

ENE 663. Water Chemistry. 3 credits, 3 contact hours.
Prerequisite: undergraduate general chemistry. The ability to analyze and solve a wide range of chemical equilibrium problems in water chemistry is developed.

ENE 664. Physical and Chemical Treatment. 3 credits, 3 contact hours.
Prerequisite: ENE 663. Physical and chemical operations and processes employed in the treatment of water and wastewater. Topics include gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.

ENE 665. Biological Treatment. 3 credits, 3 contact hours.
Prerequisites: ENE 663, ENE 661. (May be taken concurrently.) Principles of evaluation and control of water pollution that describe aerobic treatment processes: oxidation ponds, trickling filters, and activated sludge. Anaerobic digestion and sludge handling and disposal as well as biodegradability study techniques for various wastes.

ENE 666. Analysis of Receiving Waters. 3 credits, 3 contact hours.
Prerequisites or corequisites: ENE 663 and ENE 661. Ecological responses of various types of receiving waters to municipal and industrial waste loadings. Mathematical models for water quality prediction and planning.

ENE 667. Solid Waste Disposal Systems. 3 credits, 3 contact hours.
Prerequisite: ENE 663. Review and evaluation of design criteria, methods, and equipment employed in handling and disposal of industrial and municipal solid wastes. Emphasis is on hazardous toxic waste, resource recovery, and regulatory constraints.

ENE 671. Environmental Impact Analysis. 3 credits, 3 contact hours.
Prerequisite or corequisite: ENE 663. A graduate course dealing with physical aspects of the environment. Overview of environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.

ENE 672. Stormwater Management. 3 credits, 3 contact hours.
This course provides a comprehensive study of stormwater management with emphasis on design practices. Topics include regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.

ENE 673. Sustainability and Life Cycle Analysis. 3 credits, 3 contact hours.
The course provides a systematic foundation for the connection between evolving technology and human activity impacts on natural systems by emphasizing the sources of environmental degradation and energy use and strategies to reduce risk and promote sustainability. The course provides hands-on experience with life cycle assessment computer tools and approaches. The course emphasizes relationships between industrial activities and regional and global natural systems-physical, chemical and biological-focusing on the importance of sustainability goals and practices.

ENE 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of environmental engineering problems not covered by regular graduate course work is required. A student with an exceptional project in EnE may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for EnE 701 Master's Thesis.

ENE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. A written report must be submitted to the project advisor. The student cannot register in ENE 700B more than once and the incomplete (I) grade is not allowed.

ENE 701. Master'S Thesis. 0 credits, 0 contact hours.
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated for the thesis.

ENE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in ENE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ENE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (ENE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ENE 702. Special Topics in Environmental Engineering. 3 credits, 3 contact hours.
Restriction: advisor's approval. Topics of special current interest in environmental engineering.

ENE 720. Environmental Chemodynamics. 3 credits, 3 contact hours.
Introduction to concepts, mechanisms and models used to describe the transport of chemicals in the environment. Concepts and models are applied to air-water, sediment-water and soil-air interfaces.

ENE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

ENE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for ENE 726 if they have taken ENE 725 in a prior semester.

ENE 790. Doctoral Dissert & Res. 0 credits, 0 contact hours.
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

ENE 790A. Doctoral Dissert & Res. 1 credit, 1 contact hour.
Co-requisite: ENE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in ENE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

ENE 790B. Doctoral Dissert & Res. 3 credits, 3 contact hours.
Co-requisite: ENE 791. Since the ENE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

ENE 790C. Doctoral Dissertation. 6 credits, 6 contact hours.
Co-requisite: ENE 791. Since the ENE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in environmental engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

ENE 790D. Doctoral Dissertation. 9 credits, 9 contact hours.

ENE 790E. Doctoral Dissertation & Res. 12 credits, 3 contact hours.
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

ENE 790F. Doctoral Dissertation & Res. 15 credits, 3 contact hours.
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

ENE 791. Graduate Seminar. 0 credits, 0 contact hours.
Seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for ENE790 unless requirement is waived, in writing, by the dean of graduate studies.

ENE 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: ENE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in environmental engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ENE 792C. Pre-Doctoral Research. 6 credits, 3 contact hours.

Construction Management

This certificate trains individuals for highly skilled jobs in general contracting, heavy/highway and building construction, mechanical and electrical contracting, and construction management.

Who would be suited to take this program?

This certificate teaches managerial aspects of contracting and the study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning. In addition, this graduate certificate will allow professionals to specifically focus in on the legal aspect of Environmental Engineering, Construction Management or Legal, Ethical and Intellectual Property Issues for Engineering Managers.

What are the Required Courses?

Code	Title	Credits
Core Courses		
CE 610	Construction Management	3
CE 616	Construction Cost Estimating	3
CE 611	Project Planning and Control	3
Electives		
Select one of the following:		3
EM 602	Management Science	
EM 631	Legal Aspects in Environmental Engineering	
EM 632	Legal Aspects in Construction	

What will I learn?

- Construction Management where you will study an individual firm in relation to the entire construction industry.
- Construction Cost Estimating, which includes a full range of construction cost-estimating methods, such as final bid estimates for domestic building and heavy/highway projects; computerized takeoff and estimating techniques; international construction; financial and cost reporting; databases; indices; risk; competition; performance; and profit factors.
- Project Control which focuses on the methodology that can be employed to plan project implementation and control progress.
- Facility Maintenance that has a strong emphasis on planning and control of facilities use, maintenance, utility management, managerial control, budgets and costs, personnel administration, legal and safety, flexibility measurement, and design.
- Legal Aspects in Construction, incorporating contract responsibilities of contractors, engineers, and owners; subcontracts and third-party liability; construction law and code compliance; and insurance and bonds.

Why study Construction Management at NJIT?

Construction Management can be studied partially online or at our NJIT Newark campus. You'll have access to the same outstanding facilities and professors as full-time NJIT students, plus the flexibility you need to juggle all the aspects of your life.

This certificate teaches managerial aspects of contracting and the study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning. In addition, this graduate certificate will allow professionals to specifically focus in on the legal aspect of Environmental Engineering, Construction Management or Legal, Ethical and Intellectual Property Issues for Engineering Managers.

For more information about the online graduate certificate in Construction Management click here (http://engineeringmasters.njit.edu/lpkp-certcm/?utm_source=NJIT&utm_medium=website&utm_campaign=S_SearchEngine2&src=S_SearchEngine2) AND For more information about the online graduate certificate in Project Management click here. (http://engineeringmasters.njit.edu/lpkp-certcm/?utm_source=NJIT&utm_medium=website&utm_campaign=S_SearchEngine2&src=S_SearchEngine2)

Prerequisites

Applicants should have an undergraduate degree in civil engineering, engineering or its equivalent, and should have proficiency in basic sciences and mathematics. Students who lack an appropriate undergraduate background may complete bridge courses. The complete list of bridge courses is as follows:

- MATH 112 (pre-req MATH 111) (Calculus 1 and 2)
- MATH 279 (pre-req MATH 112) (Probability and Stats for Engineers)
- CE 200/200A (pre-req MATH 111) (Surveying)
- CE 210 (Construction Materials and Procedures)
- CE 341/341A (pre-req MECH 320- for this program) (Soil Mechanics)
- MECH 320 (pre-req MATH 112 and PHYS 111/111A) (Statics and Strength of Materials)
- CS 101 (Intro to Programming)

Related Degree Programs

All credits for Construction Management relates in its entirety to either NJIT MS in Civil Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/) or NJIT MS in Engineering Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/)

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/construction-management-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Heidi Young (http://directory.njit.edu/PersDetails.aspx?persid=hyoung)

ENVIRONMENTAL ENGINEERING

From the NJIT Department of Civil and Environmental Engineering, the Graduate Certificate in Environmental Engineering allows students to focus in Water Quality, Treatment and Infrastructure, Integrated Site Remediation, or Multidisciplinary Environmental Engineering. Environmental Engineers are interested in ways to protect the environment, improve water quality, and are essential in planning, designing and constructing water and wastewater treatment plants, solid waste disposal systems, site remediation approaches and emission control measures.

Who would be suited to take this program?

Eligible participants are typically employees of major corporations, government agencies, private consulting and construction firms, and universities.

What are the Required Courses?

Code	Title	Credits
Core Courses		**12**
Select four (4) of the following:		
ENE 630 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 630)	Physical Processes of Env Syst.	
ENE 661 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 661)	Environmental Microbiology	

ENE 662 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 662)	Site Remediation
ENE 664 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 664)	Physical and Chemical Treatment
ENE 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 665)	Biological Treatment
ENE 671 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 671)	Environmental Impact Analysis
ENE 672 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 672)	Stormwater Management
CE 647 (http://catalog.njit.edu/archive/2019-2020/search/?P=CE 647)	Geotechnical Aspects of Solid Waste
EM 631 (http://catalog.njit.edu/archive/2019-2020/search/?P=EM 631)	Legal Aspects in Environmental Engineering

What will I learn?

- ***Physical Processes of Environmental Systems* -** Physical processes in various media (open water, porous media) under various hydraulic regimes (laminar and turbulent). Transport by diffusion, convection, and dispersion is considered along with absorption.
- ***Environmental Microbiology* -** Microbiology of natural and human impacted environment, fundamental microbiology in water treatment engineering, microbial detection methodologies, waterborne disease outbreaks, microbial risk assessment, biotechnologies for renewable energy, and other emerging topics
- ***Site Remediation* -** Regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Established and innovative cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.
- ***Physical and Chemical Treatment* -** Physical and chemical operations and processes employed in the treatment of water and wastewater. Gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.
- ***Biological Treatment* -** Principles of evaluation and control of water pollution that describe aerobic treatment processes such as oxidation ponds, trickling filters, and activated sludge; and anaerobic processes, and sludge handling and disposal as wall as biodegradability study techniques for various wastes.
- ***Environmental Impact Analysis* -** Environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.
- ***Stormwater Management* -** With an emphasis on design practices, you will learn regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.
- ***Geotechnical Aspects of Solid Waste* -** municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems.
- ***Legal Aspects in Environmental Engineering* -** Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.

Why study Environmental Engineering at NJIT?

Students will learn to develop sustainable solutions to environmental problems, preparing to work with regional, national and global communities to protect the environment and improve water quality. Jobs in this field are essential in planning, designing and constructing water and wastewater treatment plants, solid waste disposal systems, site remediation approaches and emission control measures.

Into what industries might holders of this program find employment?

- Federal/State/Local Department of Environmental Protection (e.g., USDEP, NJDEP)

- Private consulting company conducting audits/reviews in environmental science
- Junior Civil Engineer
- Sr. Transportation Engineering Manager
- Hydrologist

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (environmental engineering, mathematics, etc.).

Related Degree Programs

All courses in this program related entirely to the NJIT MS in Environmental Enginering (https://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-ms/).

Faculty Advisor: Taha Marhaba (https://civil.njit.edu/faculty/marhaba/)

ENVIRONMENTAL SCIENCE AND ENGINEERING

A combination of both science and engineering, the Graduate Certificate in Environmental Science and Engineering at NJIT helps students solve environmental issues from both a scientific point of view as well as from an engineering point of view. The program will ultimately force a mathematical mindset to employ the scientific method when monitoring and solving real world environmental issues.

Who would be suited to take this program?

Due to the nature of engineering courses, one would want to possess an engineering background in order to be eligible for this program. Participants are typically employees of major corporations, government agencies, private consulting and construction firms, and universities.

What are the Required Courses?

Code	Title	Credits
Core Courses: choose four (4) courses in total, two (2) courses from each group.		**12**
Select two (2) of the following:		6
EVSC 610 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 610)	Environmental Chemical Science	
EVSC 612 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 612)	Environmental Analysis	
EVSC 613 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 613)	Environmental Problem Solving	
EVSC 615 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 615)	Global Environmental Problems	
EVSC 616 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 616)	Toxicology	
EVSC 627 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 627)	Environmental Microbiology	
EVSC 715 (http://catalog.njit.edu/archive/2019-2020/search/?P=EVSC 715)	Energy and Sustainability	
EM 631 (http://catalog.njit.edu/archive/2019-2020/search/?P=EM 631)	Legal Aspects in Environmental Engineering	
EPS 622 (http://catalog.njit.edu/archive/2019-2020/search/?P=EPS 622)	Sustainable Politics and Policy	
Select two (2) of the following:		6

ENE 630 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 630)	Physical Processes of Env Syst.
ENE 661 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 661)	Environmental Microbiology
ENE 662 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 662)	Site Remediation
ENE 664 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 664)	Physical and Chemical Treatment
ENE 665 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 665)	Biological Treatment
ENE 671 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 671)	Environmental Impact Analysis
ENE 672 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 672)	Stormwater Management
CE 647 (http://catalog.njit.edu/archive/2019-2020/search/?P=CE 647)	Geotechnical Aspects of Solid Waste
EM 631 (http://catalog.njit.edu/archive/2019-2020/search/?P=EM 631)	Legal Aspects in Environmental Engineering

What will I learn?

- ***Environmental Chemical Science* -** Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.
- ***Environmental Analysis*** - The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.
- ***Environmental Problem Solving*** - Solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.
- ***Global Environmental Problems*** - Relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies.
- ***Toxicology*** - The assessment of acute, sub-acute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.
- ***Environmental Microbiology* -** 1) basic microbiology: biochemical principles, cell structure organization, microbial nutrition and growth, 2) the important microbes involved in environmental microbiology and address the environments where they are found, and 3) how they are detected and monitored, and their effects on humans, and the environment.
- ***Energy and Sustainability* -** Energy fundamentals including the basic principles necessary to understand energy systems. The technological and engineered systems for processing and using different energy non-renewable and renewable sources. The social and environmental consequences of energy production, distribution, and use, including a comparison of socioeconomic models of global energy applications.
- ***Legal Aspects in Environmental Engineering* -** Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.
- ***Sustainable Politics and Policy* -** Sustainability development and institutional efforts to implement strategies at various geopolitical scales: international, national, regional, and local. The course introduces tools to measure progress toward sustainability through the use of metrics such as ecological footprint analysis and life-cycle analysis.

- ***Physical Processes of Environmental Systems -*** Physical processes in various media (open water, porous media) under various hydraulic regimes (laminar and turbulent). Transport by diffusion, convection, and dispersion is considered along with absorption.
- ***Environmental Microbiology -*** Microbiology of natural and human impacted environment, fundamental microbiology in water treatment engineering, microbial detection methodologies, waterborne disease outbreaks, microbial risk assessment, biotechnologies for renewable energy, and other emerging topics
- ***Site Remediation -*** Regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Established and innovative cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.
- ***Physical and Chemical Treatment -*** Physical and chemical operations and processes employed in the treatment of water and wastewater. Gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.
- ***Biological Treatment -*** Principles of evaluation and control of water pollution that describe aerobic treatment processes such as oxidation ponds, trickling filters, and activated sludge; and anaerobic processes, and sludge handling and disposal as wall as biodegradability study techniques for various wastes.
- ***Environmental Impact Analysis -*** Environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.
- ***Stormwater Management -*** With an emphasis on design practices, you will learn regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.
- ***Geotechnical Aspects of Solid Waste -*** municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems.

Why study Environmental Science and Engineering at NJIT?

This hybrid program allows for individuals to learn from both a theoretical point of view as well as a practical one. Students will learn to develop sustainable solutions to environmental problems, preparing to work with regional, national and global communities to protect the environment and improve water quality. Jobs in this field are essential in planning, designing and constructing water and wastewater treatment plants, solid waste disposal systems, site remediation approaches and emission control measures.

Into what industries might holders of this program find employment?

- Federal/State/Local Department of Environmental Protection (e.g., USDEP, NJDEP)
- Private consulting company conducting audits/reviews in environmental science
- Medical Centers
- Junior Civil Engineer
- Sr. Transportation Engineering Manager
- Hydrologist

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (biology, chemistry, environmental science, environmental engineering, mathematics, etc.).

Related Degree Programs

Depending on the courses selected, coursework would apply to either the NJIT MS in Environmental Science (https://catalog.njit.edu/graduate/science-liberal-arts/chemistry-environmental-science/environmental-science-ms/) or the NJIT MS in Environmental Enginering (https://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-ms/).

Faculty Advisor: Linda Cummings (https://chemistry.njit.edu/people/)

HYDROLOGY AND WATER RESOURCES ENGINEERING

From the NJIT Department of Chemicals and Materials Engineering, the Graduate Certificate in Polymers and Plastics prepares students to apply mathematical and scientific principles to the design, development and operational evaluation of synthesized macromolecular compounds and their application to specific engineering uses. This includes the development of industrial materials with tailored properties, the design of lightweight structural components, the use of liquid or solid polymers, and the analysis and control of From the NJIT Department of Civil and Environmental Engineering, the Graduate Certificate in Hydrology and Water Resources Engineering prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of systems for collecting, storing, moving, conserving and controlling surface- and groundwater, including water quality control, water cycle management, management of human and industrial water requirements, water delivery, availability, and flood control.

Who would be suited to take this program?

This program is designed Civil or Environmental Engineers in mind. Geologists and Hydrologists and public health officials must work together utilizing the techniques learned here to help build and maintain inhabitable land/towns/cities, thus both occupations would be suited for this program.

What are the Required Courses?

Code	Title	Credits
Core Courses		**12**
Select four (4) of the following:		
ENE 630 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 630)	Physical Processes of Env Syst.	
ENE 660 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 660)	Introduction to Solid and Hazardous Waste Problems	
ENE 661 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 661)	Environmental Microbiology	
ENE 663 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 663)	Water Chemistry	
ENE 672 (http://catalog.njit.edu/archive/2019-2020/search/?P=ENE 672)	Stormwater Management	
CE 618 (http://catalog.njit.edu/archive/2019-2020/search/?P=CE 618)	Applied Hydrogeology	
CE 620 (http://catalog.njit.edu/archive/2019-2020/search/?P=CE 620)	Open Channel Flow	
CE 621 (http://catalog.njit.edu/archive/2019-2020/search/?P=CE 621)	Hydrology	
MATH 715 (http://catalog.njit.edu/archive/2019-2020/search/?P=MATH 715)	Mathematical Fluid Dynamics I	

What will I learn?

- ***Physical Processes of Environmental Systems -*** Physical processes in various media (open water, porous media) under various hydraulic regimes (laminar and turbulent). Transport by diffusion, convection, and dispersion is considered along with absorption.
- ***Introduction to Solid and Hazardous Waste Problems -*** Solid waste disposal; industrial and urban sources of solid waste and conventional methods of waste disposal.
- ***Environmental Microbiology -*** The microbiology of natural and human impacted environment, fundamental microbiology in water treatment engineering, microbial detection methodologies, waterborne disease outbreaks, microbial risk assessment, biotechnologies for renewable energy, and other emerging topics that help enhance your problem-solving skills and increase your knowledge base.
- ***Water Chemistry -*** The ability to analyze and solve a wide range of chemical equilibrium problems in water chemistry.
- ***Stormwater Management -*** Regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.
- ***Applied Hydrogeology -*** Ground water and contaminant movement through the subsurface environment; aquifer geology; hydrogeologic applications including well design, pumping tests, and computer modeling of subsurface flow, and methods to monitor and remediate contaminated groundwater.
- ***Open Channel Flow -*** The principles developed in fluid mechanics are applied to flow in open channels. Steady and unsteady flow, channel controls, and transitions are considered. Application is made to natural rivers and estuaries.

- ***Hydrology -*** The statistical nature of precipitation and runoff data is considered with emphasis on floods and droughts. The flow of groundwater is analyzed for various aquifers and conditions. Flood routing, watershed yield, and drainage problems are considered.
- ***Mathematical Fluid Dynamics I -*** Introduction to the basic ideas of fluid dynamics, with an emphasis on rigorous treatment of fundamentals and the mathematical developments and issues. The course focuses on the background and motivation for recent mathematical and numerical work on the Euler and Navier-Stokes equations, and presents a mathematically intensive investigation of various model equations of fluid dynamics (e.g., the Korteweg-de-Vries equations).

Why study Hydrology and Water Resources Engineering at NJIT?

The field of hydrology is a crucial area of scientific study and employment for people interested in protecting the earth's water resources, in combating water pollution and in providing engineering hydrology. Hydrologists work in conjunction with the work of civil engineers in developing water resources infrastructure. Hydrology is the scientific study of the effects, properties and distribution of water on the earth's surface in soil, underlying rock structures and in the earth's atmosphere. The NJIT Graduate Certificate in Hydrology and Water Resources enables students to transition into this highly important field.

Into what industries might holders of this program find employment?

- Water Resources Engineering
- Hydrology
- Agriculture
- Civil Engineering

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in a related field (chemical engineering, manufacturing engineering, materials science, materials engineering, etc.).

Related Degree Programs

This graduate certificate may transition into either the NJIT MS in Civil Engineering (https://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/civil-ms/) or the NJIT MS in Environmental Engineering (https://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-ms/).

Faculty Advisor: Taha Marhaba (https://civil.njit.edu/faculty/marhaba/)

Intelligent Transportation Systems

The Intelligent Transportation Systems (ITS) Certificate Program aims on studying ITS in a systematic and focused way. This certificate program provides the current and future ITS workforce with flexible, accessible ITS learning through training, technical assistance, and educational resources. The program will assist graduate students, educators, and transportation professionals in developing their knowledge, skills, and abilities to build technical proficiency for ITS.

Who would be suited to take this program?

This certificate program is ideal for emerging Intelligent Transportation System (ITS) engineers or project managers in the field. Some job titles include:

- ITS Analyst
- ITS Project Manager
- ITS Engineer

What are the Required Courses?

Code	Title	Credits
Core Courses		
TRAN 615	Traffic Studies and Capacity	3
TRAN 755	Intelligent Transportation Systems	3
TRAN 698 Advanced Transportation Modeling		3
Electives		
Select one of the following:		3
TRAN 602	Geographic Information Systems	

IS 531	Database Fundamentals
CS 631	Data Management System Design

What will I learn?

- *Traffic Studies and Capacity* - 1) elementary probability and statistics; 2) characteristics of the traffic stream; 3) fundamental traffic flow relationships. Also, the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections.
- *Intelligent Transportation Systems Introduction* - The fundamentals of ITS, including ITS national/regional architectures, designing process, and the state-of-the-practice technologies used to improve the safety, efficiency and control of surface transportation systems, including Connected Vehicles.Technological and operational issues of ITS and using them for advanced traffic management and connected vehicles.
- *Advanced Transportation Modeling* - Discuss advanced modeling techniques for the evaluation of ITS applications. The modeling techniques covered will include Macroscopic, Mesoscopic, and Microscopic modeling tools to hone students' hands-on skills and practical experience for ITS project design and evaluation.
- *Geographic Information System* - Geographic Information System (GIS) and its applications for Intelligent Transportation Systems (ITS). Topics include fundamental data structures and basic functions, methods of data capture and sources of data, and the nature and characteristics of spatial data and objects. Students will be designing, building, querying, updating, maintaining and managing relational databases, using the Structured Query Language (SQL).
- *Database Fundamentals* - extensive, pragmatic experience in designing, building, querying, updating, maintaining and managing relational databases, using the Structured Query Language (SQL). You will also learn logical and physical database design. SQL will be extensively covered, and students will design and implement sophisticated SQL queries.
- *Data Management System Design* - methods of database design and conceptual modeling, physical storage for database information and fundamental notions of concurrency control and recovery in database systems. This topic requires basic knowledge of data structures and relational database technology.

Why study Intelligent Transportation Design (ITS) at NJIT?

NJIT has long been offering both the MS in Transportation, for transportation engineers, and the MS in Computer Science, for technology journeymen. This program combines the strengths of both in tightly focused package.

Into what industries might holders of this program find employment?

- Federal/State/Local Department of Transportation (e.g., USDOT, NJ DOT)
- Private consulting company conducting ITS Design, Operation, and Evaluation (e.g., Cambridge Systematics, Leidos, Booz Allen Hamilton)
- Information Technology (IT) company developing ITS, Smart City, and Connected Vehicle technologies and applications (e.g., SIEMENS, IBM)

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in economics, mathematics, probability and statistics, and computers (specifically, database design). Students who lack an appropriate background may be admitted and required to make up deficiencies by taking a program of courses designed in consultation with graduate advisors.

Related Degree Programs

Faculty Advisor: Joyoung Lee (http://civil.njit.edu/people/Lee.php)

M.S. in Civil Engineering

Degree Requirements

Students who do not have a bachelor's degree in civil engineering, but who want to obtain a master's degree in civil engineering must complete a bridge program for their chosen area of specialization. These courses are not counted for degree credit. See the areas of specialization in this section for specific bridge programs. Please note that prerequisites for bridge courses also must be met. See the undergraduate catalog for descriptions of 100- to 400-level courses. Some of the bridge courses may be waived depending on the student's background.

The program as shown below offers numerous areas of specialization, each with its own list of required and elective courses and bridge program. Once the choice of specialization is made, the student consults his/her specialization advisor to plan and develop an individualized and cohesive sequence of courses that will meet the program requirements of at least 30 degree credits.

Other suitable electives may be taken subject to approval of program advisor.

Students receiving financial aid at any point in their studies must complete 6 credits of CE 701 Masters Thesis. Any students are able to substitute Master's thesis in their program.

M.S. in Civil Engineering, Construction Engineering and Management

Code	Title	Credits
Bridge Program		
CE 210	Construction Materials and Procedures	3
CE 501	Introduction to Soil Behavior	3
MECH 320	Statics and Strength of Materials	3
CS 101	Computer Programming and Problem Solving	3
MATH 225	Survey of Probability and Statistics	1
MATH 112	Calculus II	4
Total Credits		17

Code	Title	Credits
Core Courses		
CE 610	Construction Management	3
CE 611	Project Planning and Control	3
Specialty Electives		
Select four to six of the following:		12-18
CE 614	Underground Construction	
CE 615	Infrastructure and Facilities Remediation	
CE 616	Construction Cost Estimating	
CE 617	Historic Preservation	
CE 644	Geology in Engineering	
CE 700	Master's Project	
CE 671	Performance and Risk Analysis of Infrastructure Systems	
General Electives		
Select zero to two from the List of Department General Electives		0-6
Management/Leadership Electives		
Select one to two of the following:		3-6
CE 711	Methods Improvement in Construction	
EM 632	Legal Aspects in Construction	
HRM 601	Organizational Behavior	
Total Credits		30

[1] Students receiving departmental awards are required to write a thesis.

[2] All students who receive departmental or research-based awards must enroll in the seminar each semester.

M.S. in Civil Engineering, Environmental Engineering, Water Quality Program

Code	Title	Credits
Water Quality Bridge Program		
CE 320	Fluid Mechanics	3
CE 321	Water Resources Engineering	3
CHEM 126	General Chemistry II	3
Total Credits		9

Code	Title	Credits
Core Courses		
ENE 663	Water Chemistry	3
ENE 661	Environmental Microbiology	3
or EVSC 627	Environmental Microbiology	
Specialty Electives		

Select four to six of the following:		12-18
ENE 664	Physical and Chemical Treatment	
ENE 665	Biological Treatment	
ENE 672	Stormwater Management	
CE 671	Performance and Risk Analysis of Infrastructure Systems	
General Electives		
Select zero to two from the List of Department General Electives		0-6
Management/Leadership Electives		
Select one to two of the following:		3-6
CE 610	Construction Management	
CE 711	Methods Improvement in Construction	
EM 631	Legal Aspects in Environmental Engineering	
HRM 601	Organizational Behavior	
Total Credits		30

M.S. in Civil Engineering, Environmental Engineering Integrated Site Remediation

Code	Title	Credits
Integrated Site Remediation Bridge Program		
CHEM 126	General Chemistry II	3
CE 321	Water Resources Engineering	3
CE 501	Introduction to Soil Behavior	3
Total Credits		9

Code	Title	Credits
Core Courses		
ENE 663	Water Chemistry	3
ENE 661	Environmental Microbiology	3
or EVSC 627	Environmental Microbiology	
Specialty Electives		
Select four to six of the following:		12-18
ENE 660	Introduction to Solid and Hazardous Waste Problems	
ENE 662	Site Remediation	
ENE 671	Environmental Impact Analysis	
CE 602	Geographic Information System	
General Electives		
Select zero to two from the List of Department General Electives		0-6
Management/Leadership Electives		
Select one to two of the following:		3-6
CE 610	Construction Management	
CE 711	Methods Improvement in Construction	
EM 631	Legal Aspects in Environmental Engineering	
HRM 601	Organizational Behavior	
Total Credits		30

M.S. in Civil Engineering, Geotechnical Engineering

Code	Title	Credits
Bridge Program		
CE 320	Fluid Mechanics	3
CE 332	Structural Analysis	3
CE 333	Reinforced Concrete Design	2
CE 341	Soil Mechanics	3
CE 341A	Soil Mechanics Laboratory	1

CE 443	Foundation Design	3
CS 101	Computer Programming and Problem Solving	3
MATH 322	Differential Equations for Applications	3

Core Courses

Students must attain a minimum GPA of 3.0 in the three core courses listed below:

Code	Title	Credits
Core Courses		
CE 641	Engineering Properties of Soils	3
CE 643	Advanced Foundation Engineering	3
CE 648	Flow Through Soils	3
Advanced Geotechnical Design Courses		
Select 2-3 courses from the following:		
CE 642	Foundation Engineering	
CE 647	Geotechnical Aspects of Solid Waste	
CE 742	Geotechnology of Earthquake Engineering	
CE 646	Geosynthetics & Soil Imp	
Geology/Rock Mechanics Courses		
Select 1-2 courses from the following:		0-6
CE 644	Geology in Engineering	
CE 614	Underground Construction	
CE 602	Geographic Information System	
or MIP 652	Geographic Information Systems	
Pending Extraction and Storage of Energy Resources		
General Electives		
Select 0-4 courses from the following:		
Pavements		
CE 553	Design and Construction of Asphalt Pavements	
CE 649	Design & Construction of Concr	
CE 659	Flexible and Rigid Pavements	
CE 702	Special Topics in Civil Engineering	
Pending Management of Infrastructure Assets		
Structural		
CE 615	Infrastructure and Facilities Remediation	
CE 631	Advanced Reinforced Concrete Design	
CE 638	Nondestructive Testing Methods in Civil Engineering	
Numerical Methods		
ME 622	Finite Element Methods in Mechanical Engineering	
MATH 614	Numerical Methods I	
Management/Leadership Electives		
Select 3-6 credits from the following:		
CE 610	Construction Management	
CE 611	Project Planning and Control	
CE 616	Construction Cost Estimating	
CE 711	Methods Improvement in Construction	
EM 632	Legal Aspects in Construction	
HRM 601	Organizational Behavior	

Students pursuing a thesis option or receiving financial aid at any point in their studies must complete a minimum of 6 credits of CE 701 Master’s Thesis in place of 3 credits reduction from the Advanced Geotechnical Design Courses Requirements and 3 Credits reduction from the Management/Leadership

M.S. in Civil Engineering, Structural Engineering

Code	Title	Credits
Bridge Program		
CE 333	Reinforced Concrete Design	2
CE 341	Soil Mechanics	3
CE 341A	Soil Mechanics Laboratory	1
CE 432	Steel Design	2
CS 101	Computer Programming and Problem Solving	3
MATH 222	Differential Equations	4
MECH 236	Dynamics	2
Total Credits		17

Code	Title	Credits
Core Courses		
CE 639	Applied Finite Element Methods	3
CE 636	Mechanics and Stability of Structures	3
Specialty Electives		
Select four to six of the following:		12-18
CE 531	Design of Masonry and Timber Structures	
CE 631	Advanced Reinforced Concrete Design	
CE 632	Prestressed Concrete Design	
CE 634	Structural Dynamics	
CE 635	Fracture Mechanics of Engineering Materials	
CE 637	Short Span Bridge Design	
CE 638	Nondestructive Testing Methods in Civil Engineering	
CE 700	Master's Project	
CE 702	Special Topics in Civil Engineering	
CE 730	Plastic Analysis and Design	
CE 733	Design of Metal Structures	
CE 734	Design of Tall Buildings and Space Structures	
CE 736	Finite Element Methods in Structural and Continuum Mechanics	
CE 737	Earthquake Engineering	
CE 739	Structural Optimization	
MECH 630	Theory Of Elasticity	
General Electives		
Select zero to two from the List of Department General Electives		0-6
Management/Leadership Electives		
Select one to two of the following:		3-6
CE 610	Construction Management	
CE 711	Methods Improvement in Construction	
EM 632	Legal Aspects in Construction	
HRM 601	Organizational Behavior	
Total Credits		30

M.S. in Civil Engineering, Transportation Engineering

Code	Title	Credits
Bridge Program		
CE 350	Transportation Engineering	3
CS 101	Computer Programming and Problem Solving	3
ECON 265	Microeconomics	3
MATH 105	Elementary Probability and Statistics	3

MATH 309	Mathematical Analysis for Technology	4
Total Credits		16

Code	Title	Credits
Core Courses		
TRAN 650	Urban Systems Engineering	3
TRAN 615	Traffic Studies and Capacity	3
Specialty Electives		
Select four to six of the following:		12-18
CE 659	Flexible and Rigid Pavements	
TRAN 552	Geometric Design of Transportation Facilities	
TRAN 603	Introduction to Urban Transportation Planning	
TRAN 625	Public Transportation Operations and Technology	
TRAN 653	Traffic Safety	
TRAN 655	Land Use Planning	
TRAN 700	Masters Project	
TRAN 752	Traffic Control	
Management/Leadership Electives		
Select two of the following:		6
CE 711	Methods Improvement in Construction	
EM 632	Legal Aspects in Construction	
HRM 601	Organizational Behavior	
Total Credits		24-30

M.S. in Critical Infrastructure Systems

Degree Requirements

A minimum of 30 degree credits, not including any bridge courses, is required. Candidates must consult with the graduate advisor (not thesis advisor) in designing appropriate programs of study.

Students must attain a minimum GPA of 3.0 in the core courses listed below, and a minimum overall GPA of 3.0.

Master of Science in Critical Infrastructure Systems

Code	Title	Credits
Core Courses		
4 Core Courses are required and are: [1]		12
CE 671	Performance and Risk Analysis of Infrastructure Systems	
CE 672	Security Management of Critical Infrastructure	
EM 602	Management Science	
MIP 675	Elements of Infrastructure Planning	
Electives		
Select six courses (or 4 courses and a Thesis) from the following:		18
Critical Infrastructure Life-Cycle Management (CILC)		
Planning and Facilities Management:		
CE 602	Geographic Information System	
CE 615	Infrastructure and Facilities Remediation	
Engineered Systems:		
TRAN 705	Mass Transportation Systems	
ECE 610	Power System Steady-State Analysis	
ECE 637	Internet and Higher-Layer Protocols	
ECE 683	Computer Network Design and Analysis	
ECE 673	Random Signal Analysis I	
ECE 642	Communication Systems I	

Program/Impact Management:		
CE 610	Construction Management	
CE 611	Project Planning and Control	
CE 616	Construction Cost Estimating	
IE 651	Industrial Simulation	
IE 605	Engineering Reliability	
IE 614	Safety Engineering Methods	
ENE 662	Site Remediation	
ENE 663	Water Chemistry	
ENE 671	Environmental Impact Analysis	
HRM 601	Organizational Behavior	
Critical Infrastructure Security and Emergency Management (CISE)		
Emergency and Preparedness Management (Joint UMDNJ):		
IS 613	Design of Emergency Management Information Systems	
IS 614	Command and Control Systems	
Enabling Systems and Technologies:		
MIS 648	Decision Support Systems for Managers	
TRAN 615	Traffic Studies and Capacity	
TRAN 752	Traffic Control	
TRAN 755	Intelligent Transportation Systems	
EM 771	Operations Cost and Management Control	
MGMT 635	Data Mining and Analysis	
MGMT 650	Knowledge Management	
CS 631	Data Management System Design	
CS 632	Advanced Database System Design	
CS 782	Pattern Recognition and Applications	
IE 706	A Queueing Approach to Performance Analysis	
IE 621	Systems Analysis and Simulation	
Public Health Systems and Emergency Preparedness:		
RBHS Courses		
Principles and Methods of Epidemiology		
Introduction to Environmental Health		
Public Health Preparedness I:Agents of Mass Injury or Destruction		
Public Health Preparedness II:Emergency Management and Response		
Health/Risk Communications		
Other Electives: Master's Thesis [2]		
Total Credits		30

1 Students receiving financial aid at any point in their studies must complete 6 credits of CE 701 Masters Thesis.

2 Other suitable electives may be taken subject to approval of program advisor, particularly in the area of Public Health Systems and Emergency Preparedness.

M.S. in Environmental Engineering

Degree Requirements

Students who lack appropriate background are asked to make up deficiencies by taking a program of bridge courses, including any prerequisites, that is designed in consultation with graduate advisors. See the **undergraduate catalog** for description of bridge courses.

The program comprises 30 credits of required and elective courses. The student consults the graduate advisor to plan and maintain an individualized and cohesive sequence of courses.

Students receiving financial aid at any point in their studies must complete 6 credits of ENE 701 Master'S Thesis. Any students are able to substitute Master’s thesis in their program.

M.S. in Environmental Engineering

Code	Title	Credits
Bridge Courses		
CE 320	Fluid Mechanics	3
CE 321	Water Resources Engineering	3
CE 322	Hydraulic Engineering	3
CE 501	Introduction to Soil Behavior	3
CHEM 126	General Chemistry II	3
CS 101	Computer Programming and Problem Solving	3
MATH 222	Differential Equations	4
MECH 234	Engineering Mechanics	2
MECH 236	Dynamics	2
Total Credits		26

Code	Title	Credits
Required Courses		
ENE 663	Water Chemistry	3
ENE 660	Introduction to Solid and Hazardous Waste Problems	3
ENE 661	Environmental Microbiology	3
Graduate mathematics or computer science course approved by graduate advisor		3
Electives		
Select six of the following:		18
CE 602	Geographic Information System	
CE 605	Research Methods in Remote Sensing	
CE 618	Applied Hydrogeology	
CE 620	Open Channel Flow	
CE 621	Hydrology	
CE 623	Groundwater Hydrology	
CE 647	Geotechnical Aspects of Solid Waste	
CE 702	Special Topics in Civil Engineering	
ENE 662	Site Remediation	
ENE 664	Physical and Chemical Treatment	
ENE 665	Biological Treatment	
ENE 666	Analysis of Receiving Waters	
ENE 671	Environmental Impact Analysis	
ENE 672	Stormwater Management	
ENE 700	Master'S Project	
ENE 702	Special Topics in Environmental Engineering	
ENE 720	Environmental Chemodynamics	
Total Credits		30

M.S. in Transportation

Degree Requirements

Students who lack an appropriate background may be admitted and required to make up deficiencies by taking a program of bridge courses designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements. See the undergraduate catalog for descriptions of 100 to 400-level courses. Students may be required to take or demonstrate that they already have taken courses equivalent to the bridge courses.

Students must select one area of specialization and take a minimum of 30 credits. TRAN 792 Pre-Doctoral Research is required for all students who receive departmental or research-based awards. A maximum of 6 credits may be taken from the 500-level courses for the master of science.

Three general areas of specialization are available. While they share a common methodological core, each is designed to suit various interests:

- **Transportation Engineering** focuses on traffic engineering, physical design and operational aspects of transportation systems. This area is best suited for students with an undergraduate engineering degree.
- **Transportation Planning** emphasizes the analysis and planning aspects, in particular the integration of transportation systems with urban and regional considerations such as economics, land use, and the environment.
- **Advanced Transportation Systems and Technologies** emphasizes the use of emerging technologies such as intelligent transportation systems in planning, design and operations of multi- and inter-modal transportation systems.

Additional elective courses for all areas of specialization may be taken with approval of the graduate advisor.

Students receiving financial aid at any point in their studies must complete 6 credits of TRAN 701 Master's Thesis. Any students are able to substitute Master’s thesis in their program.

M.S. in Transportation Engineering

Code	Title	Credits
Bridge Courses		
CE 350	Transportation Engineering [1]	3
CS 101	Computer Programming and Problem Solving	3
ECON 265	Microeconomics	3
MATH 105	Elementary Probability and Statistics	3
MATH 309	Mathematical Analysis for Technology	4
Total Credits		16

[1] Students who have demonstrated professional transportation work experience may have this course waived.

Code	Title	Credits
Core Courses		
TRAN 603	Introduction to Urban Transportation Planning	3
TRAN 610	Transportation Economics	3
TRAN 650	Urban Systems Engineering	3
or EM 602	Management Science	
Area of Specialization Required Courses		
TRAN 615	Traffic Studies and Capacity	3
TRAN 625	Public Transportation Operations and Technology	3
TRAN 752	Traffic Control	3
Electives		
Select four of the following:		12
CE 611	Project Planning and Control	
EM 691	Cost Estimating for Capital Projects	
ENE 671	Environmental Impact Analysis	
HRM 601	Organizational Behavior	
IE 651	Industrial Simulation	
MATH 661	Applied Statistics	
ME 635	Computer-Aided Design	
MGMT 692	Strategic Management	
MIS 648	Decision Support Systems for Managers	
TRAN 552	Geometric Design of Transportation Facilities	
TRAN 602	Geographic Information Systems	
TRAN 608	Behavioral Issues in Transportation Studies	
TRAN 640	Distribution Logistics	
TRAN 653	Traffic Safety	
TRAN 659	Flexible and Rigid Pavements	
TRAN 753	Airport Design and Planning	
TRAN 754	Port Design and Planning	
TRAN 755	Intelligent Transportation Systems	

TRAN 760	Urban Trans Networks	
Total Credits		30

M.S. in Transportation Planning

Code	Title	Credits
Bridge Courses		
CE 350	Transportation Engineering [1]	3
CS 101	Computer Programming and Problem Solving	3
ECON 265	Microeconomics	3
MATH 105	Elementary Probability and Statistics	3
MATH 309	Mathematical Analysis for Technology	4
Total Credits		16

[1] Students who have demonstrated professional transportation work experience may have this course waived.

Code	Title	Credits
Core Courses		
TRAN 603	Introduction to Urban Transportation Planning	3
TRAN 610	Transportation Economics	3
TRAN 650	Urban Systems Engineering	3
or EM 602	Management Science	
Area of Specialization Required Courses		
TRAN 655	Land Use Planning	3
TRAN 625	Public Transportation Operations and Technology	3
or TRAN 705	Mass Transportation Systems	
TRAN 765	Multi-modal Freight Transportation Systems Analysis	3
Electives		
Select four of the following:		12
CE 611	Project Planning and Control	
ENE 671	Environmental Impact Analysis	
HRM 601	Organizational Behavior	
HRM 606	Human Resource Management	
MATH 661	Applied Statistics	
MGMT 691	Legal and Ethical Issues	
MGMT 692	Strategic Management	
MIS 620	E-Commerce Technologies	
TRAN 602	Geographic Information Systems	
TRAN 608	Behavioral Issues in Transportation Studies	
TRAN 615	Traffic Studies and Capacity	
TRAN 640	Distribution Logistics	
TRAN 643	Transportation Finance	
TRAN 653	Traffic Safety	
TRAN 720	Discrete Choice Modeling for Travel Demand Forecasting	
TRAN 753	Airport Design and Planning	
TRAN 755	Intelligent Transportation Systems	
Total Credits		30

Advanced Transportation Systems and Technologies

Code	Title	Credits
Bridge Courses		
CE 350	Transportation Engineering [1]	3
CS 101	Computer Programming and Problem Solving	3
ECON 265	Microeconomics	3

MATH 105	Elementary Probability and Statistics	3
MATH 309	Mathematical Analysis for Technology	4
Total Credits		16

[1] Students who have demonstrated professional transportation work experience may have this course waived.

Code	Title	Credits
Core Courses		
TRAN 603	Introduction to Urban Transportation Planning	3
TRAN 610	Transportation Economics	3
TRAN 650	Urban Systems Engineering	3
or EM 602	Management Science	
Area of Specialization Required Courses		
TRAN 615	Traffic Studies and Capacity	3
TRAN 755	Intelligent Transportation Systems	3
TRAN 765	Multi-modal Freight Transportation Systems Analysis	3
Electives		
Select four of the following:		12
CS 610	Data Structures and Algorithms	
CS 651	Data Communications	
CS 661	Systems Simulation	
ECE 642	Communication Systems I	
EM 714	Multicriteria Decision Making	
ENE 671	Environmental Impact Analysis	
HRM 601	Organizational Behavior	
IE 624	Heuristic Methods	
IE 642	Network Flows and Applications	
IE 644	Application of Stochastic Modeling in Systems Control	
IE 651	Industrial Simulation	
IE 705	Mathematical Programming in Management Science	
IE 706	A Queueing Approach to Performance Analysis	
MATH 661	Applied Statistics	
ME 635	Computer-Aided Design	
MIS 648	Decision Support Systems for Managers	
MRKT 636	Design and Development of High Technology Products	
TRAN 602	Geographic Information Systems	
TRAN 608	Behavioral Issues in Transportation Studies	
TRAN 625	Public Transportation Operations and Technology	
TRAN 640	Distribution Logistics	
TRAN 752	Traffic Control	
Total Credits		30

M.S. Online in Civil Engineering

Degree Requirements

Students who lack an appropriate background are asked to make up deficiencies by taking a program of bridge courses that is designed in consultation with the graduate advisor. These courses are not typically available online and taken in addition to the degree requirements. Please note that the prerequisites for bridge course must also be met.

A minimum of 30 credits, not including any bridge courses, is required. Candidates must consult with the graduate advisor (not thesis advisor) in designing appropriate programs of study.

Students must attain a minimum GPA of 3.0 in the core courses listed bellow, and a minimum overall GPA of 3.0.

Students receiving financial aid at any point in their studies must complete 6 credits of CE 701 Masters Thesis. Any students are able to substitute Master's thesis in their program.

Online M.S. in Civil Engineering

Code	Title	Credits
Bridge Courses		
CS 101	Computer Programming and Problem Solving	3
ECON 265	Microeconomics	3
MATH 112	Calculus II	4
MATH 105	Elementary Probability and Statistics	3
MECH 320	Statics and Strength of Materials	3
CE 200	Surveying	2
or CE 200A	Surveying Laboratory	
CE 210	Construction Materials and Procedures	3
CE 320	Fluid Mechanics	3
CE 321	Water Resources Engineering	3
CE 341	Soil Mechanics	3
CE 350	Transportation Engineering	3
Total Credits		33

Code	Title	Credits
Core Courses		
CE 610	Construction Management	3
CE 611	Project Planning and Control	3
CE 616	Construction Cost Estimating	3
CE 620	Open Channel Flow	3
CE 621	Hydrology	3
TRAN 603	Introduction to Urban Transportation Planning	3
TRAN 752	Traffic Control	3
Management/Leadership Electives		
EM 602	Management Science	3
HRM 601	Organizational Behavior	3
EM 631	Legal Aspects in Environmental Engineering	3
Total Credits		30

Ph.D. in Civil Engineering

Degree Requirements

The department approves specific degree requirements and dissertation topics on an individual basis. Students must attain a minimum overall GPA of 3.0. Students must conduct independent original research in a specific area of civil engineering. Students must select an advisor willing to supervise dissertation work.

Ph.D. in Civil Engineering (students entering with a master’s degree in civil engineering or equivalent)

Code	Title	Credits
Electives		
700-level course work [1]		12
Dissertation		
CE 790	Doct Dissertation & Res [2]	
CE 792	Pre-Doctoral Dissertation [2]	
Seminar		
CE 791	Graduate Seminar [3]	
Total Credits		12

[1] No more than 3 credits may be received for CE 725 (Independent Study) and no more than 3 credits may be received for CE 726 (Independent Study). 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements.

[2] Ph.D. students who pass the Qualifying Examination (QE) must register for 3 credits of pre-doctoral research (CE 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal.
Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (CE 790 Doctoral Dissertation & Research) each semester until they complete all degree requirements

[3] Required of all doctoral students every semester.

Ph.D. in Civil Engineering (students entering with only a baccalaureate degree in civil engineering or equivalent)

Code	Title	Credits
Electives		
600-700-level course work [1]		36
Dissertation		
CE 790	Doct Dissertation & Res [2]	
CE 792	Pre-Doctoral Dissertation [2]	
Seminar		
CE 791	Graduate Seminar [3]	
Total Credits		36

[1] A minimum of 12 credits of this requirement must be 700 level courses. No more than 3 credits may be received for CE 725 (Independent Study) and no more than 3 credits may be received for CE 726 (Independent Study). 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements

[2] Ph.D. students who pass the Qualifying Examination (QE) must register for 3 credits of pre-doctoral research (CE 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal.
Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (CE 790 Doct Dissertation & Res) each semester until they complete all degree requirements.

[3] Required of all doctoral students every semester.

Preliminary Qualifying Examination
Full-time students must take the preliminary qualifying exam for the first time within one year of beginning active study and must pass it completely by the next time the examination is offered. Part-time students must take the preliminary qualifying exam for the first time within three years of the beginning of active study and must pass it completely by the next time the examination is offered. Exceptional students having only bachelor's degrees who are admitted directly into the doctoral program must take the preliminary qualifying examination within one and one-half years of admission and must pass it within two years. All students are permitted to take the examination only twice.

Dissertation Committee
The committee consists of a minimum of five members, one of whom is external to the Ph.D. program or to NJIT. The majority of the committee members are NJIT Graduate Faculty from the student's program or department having research experience or developing research interests related to the dissertation research. The dissertation committee chairperson typically is the doctoral candidate's dissertation advisor. This chairperson must be a tenured or tenure-track faculty member in the program. Two committee members, including an external member, may serve as co-advisors. The advisor, or at least one of the co-advisors, must be a tenured or tenure-track faculty member from the program. The other members of the dissertation committee, except for an external member from outside the university, must be members of NJIT's Graduate Faculty. Former students of any committee member, who are less than four years beyond doctoral completion, are specifically excluded from membership. The external members should either have appropriate faculty rank elsewhere or have sufficient research expertise.

Research Proposal
Doctoral students must prepare a written research proposal and make an oral presentation for approval by their dissertation committee. The proposal must be presented after formation of the committee but within twelve months after passing the qualifying examination. Research is expected to investigate or develop a unique contribution to science and technology.

Dissertation Defense
An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Ph.D. in Environmental Engineering

Degree Requirements

The department approves specific degree requirements and dissertation topics on an individual basis. Students must attain a minimum overall GPA of 3.0. Students must conduct independent original research in a specific area of environmental engineering. Students must select an advisor willing to supervise dissertation work.

Code	Title	Credits
Electives		
700-level course work [1]		12
Dissertation		
ENE 790	Doctoral Dissert & Res [2]	
ENE 792	Pre-Doctoral Research [2]	
Seminar		
ENE 791	Graduate Seminar [3]	
Total Credits		12

1. No more than 3 credits may be received for ENE 725 (Independent Study) and no more than 3 credits may be received for ENE 726 (Independent Study). 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements
2. Ph.D. students who pass the Qualifying Examination (QE) must register for 3 credits of pre-doctoral research (ENE 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal.
   Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (ENE 790 Doctoral Dissertation & Research) each semester until they complete all degree requirements.
3. Required of all full-time doctoral students every semester.

Ph.D. in Environmental Engineering (students entering with only a baccalaureate degree in environmental engineering or equivalent)

Code	Title	Credits
Electives		
600-700-level course work [1]		36
Dissertation		
ENE 790	Doctoral Dissert & Res [2]	
ENE 792	Pre-Doctoral Research [2]	
Seminar		
ENE 791	Graduate Seminar [3]	0
Total Credits		36

1. A minimum of 12 credits of this requirement must be 700 level courses. No more than 3 credits may be received for ENE 725 (Independent Study) and no more than 3 credits may be received for ENE 726 (Independent Study). 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements
2. Ph.D. students who pass the Qualifying Examination (QE) must register for 3 credits of pre-doctoral research (ENE 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal.
   Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (ENE 790 Doctoral Dissertation & Research) each semester until they complete all degree requirements.
3. Required of all full-time doctoral students every semester.

Qualifying Examination

Full-time students must take the qualifying examination for the first time within one year of beginning active study and must pass it completely by the next time the examination is offered. Part-time students must take the qualifying examination for the first time within three years of the beginning of active study and must pass it completely by the next time it is offered. Exceptional students having only bachelor's degrees who are admitted directly into the doctoral program must take the qualifying examination within one and one-half years of admission and must pass it within two years. All students are permitted to take the examination only twice.

Dissertation Committee

The committee consists of a minimum of five members, one of whom is external to the Ph.D. program or to NJIT. The majority of the committee members are NJIT Graduate Faculty from the student's program or department having research experience or developing research interests related to the dissertation research. The dissertation committee chairperson typically is the doctoral candidate's dissertation advisor. This chairperson must be a tenured or tenure-track faculty member in the program. Two committee members, including an external member, may serve as co-advisors. The advisor, or at least one of the co-advisors, must be a tenured or tenure-track faculty member from the program. The other members of the dissertation committee, except for an external member from outside the university, must be members of NJIT's Graduate Faculty. Former students of any committee member, who are less than four years beyond doctoral completion, are specifically excluded from membership. The external members should either have appropriate faculty rank elsewhere or have sufficient research expertise.

Research Proposal
Doctoral students must prepare a written research proposal and make an oral presentation for approval by their dissertation committee. The proposal must be presented after formation of the committee but within twelve months after passing the qualifying examination. Research is expected to investigate or develop a unique contribution to science and technology.

Dissertation Defense
An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Ph.D. in Transportation Engineering

Degree Requirements

Independent original research must be conducted by the candidate in a specific area of transportation. Dissertation work must be of publishable quality.

Ph.D. in Transportation Engineering (students entering with a master's degree in transportation engineering or equivalent)

Code	Title	Credits
Electives		
700-level courses [1]		12
Dissertation		
TRAN 790	Doctoral Dissertation [2]	0
TRAN 792	Pre-Doctoral Research [2]	0
Seminar		
TRAN 791	Doctoral Seminar [3]	0
Total Credits		12

1. No more than 3 credits may be received for TRAN 725 (Independent Study) and no more than 3 credits may be received for TRAN 726 (Independent Study). 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements
2. Ph.D. students who pass the Qualifying Examination (QE) must register for 3 credits of pre-doctoral research (TRAN 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal.
Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (TRAN 790 Doctoral Dissertation & Research) each semester until they complete all degree requirements.
3. Required of all full-time doctoral students every semester.

Ph.D. in Transportation Engineering (students entering with only a baccalaureate degree in transportation engineering or equivalent)

Code	Title	Credits
Electives		
600-700-level courses [1]		36
Dissertation		
TRAN 790	Doctoral Dissertation	0
TRAN 792	Pre-Doctoral Research [2]	0
Seminar		
TRAN 791	Doctoral Seminar [3]	0
Total Credits		36

1 A minimum of 12 credits of this requirement must be 700 level courses. No more than 3 credits may be received for TRAN 725 (Independent Study) and no more than 3 credits may be received for TRAN 726 (Independent Study). 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. A Ph.D. student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements

2 Ph.D. students who pass the Qualifying Examination (QE) must register for 3 credits of pre-doctoral research (TRAN 792 Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal.
Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (TRAN 790 Doctoral Dissertation & Research) each semester until they complete all degree requirements.

3 Required of all full-time doctoral students every semester.

Qualifying Examination

All doctoral students must pass a doctoral qualifying examination. To prepare adequately for the examination, students should take appropriate course work in transportation as well as other related subjects.

The examination has four parts: the first three are written, and the fourth is oral. The oral part is a presentation made to the graduate faculty in Transportation and is given after the written parts are evaluated.

·Part I Analytical Techniques

·Part II Transportation Facilities and Operations

·Part III Transportation Planning and Technologies

·Part IV Oral (includes a field problem)

For additional information about doctoral degree requirements, refer to the **Academic Policies and Procedures** section.

Dissertation Committee

The committee consists of a minimum of five members, one of whom is external to the Ph.D. program or to NJIT. The majority of the committee members are NJIT Graduate Faculty from the student's program or department having research experience or developing research interests related to the dissertation research. The dissertation committee chairperson typically is the doctoral candidate's dissertation advisor. This chairperson must be a tenured or tenure-track faculty member in the program. Two committee members, including an external member, may serve as co-advisors. The advisor, or at least one of the co-advisors, must be a tenured or tenure-track faculty member from the program. The other members of the dissertation committee, except for an external member from outside the university, must be members of NJIT's Graduate Faculty. Former students of any committee member, who are less than four years beyond doctoral completion, are specifically excluded from membership. The external members should either have appropriate faculty rank elsewhere or have sufficient research expertise.

Research Proposal
Doctoral students must prepare a written research proposal and make an oral presentation for approval by their dissertation committee. The proposal must be presented after formation of the committee but within twelve months after passing the qualifying examination. Research is expected to investigate or develop a unique contribution to science and technology.

Dissertation

A program committee must approve a dissertation topic and an NJIT faculty member, approved by the program, must be available to supervise the dissertation research. An oral defense of the dissertation is required after the dissertation committee accepts the written document.

Transportation Studies

Transportation is vital to our society's proper functioning, providing mobility of people, goods and services. It enables people to access job markets and participate in recreational, cultural, educational, and social activities. It adds value to products by moving them to their destination in time for their use. The transportation field also is a major contributor to the economy, as a consumer of resources and as a supplier of jobs.

Who is suited for this program?

Students whose goals are to become transportation planners, engineers, and managers who can plan, design, operate, and manage transportation systems capable of satisfying society's transportation needs.

What are the Required Courses?

Code	Title	Credits
Core Courses		
TRAN 603	Introduction to Urban Transportation Planning	3

TRAN 650	Urban Systems Engineering	3
TRAN 752	Traffic Control	3
Electives		
Select one of the following:		3
TRAN 610	Transportation Economics	3
TRAN 625	Public Transportation Operations and Technology	3
TRAN 640	Distribution Logistics	3

What will I learn?

- Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined.
- Various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods, mathematical modeling and simulation, and decision making under uncertainty.
- Traffic laws and ordinances; regulatory measures; traffic control devices; markings, signs and signals; timing of isolated signals; timing and coordination of arterial signal systems; operational controls; flow, speed, parking; principles of transportation system management/ administration; highway lighting; and state-of-the-art surveillance and detection devices and techniques. Hands-on experience with TRAF/NETSIM and FREESIM.
- Principles of engineering economy. Cost of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements.
- Presentation of the technological and engineering aspects of public transportation systems. Historical development of public transportation technologies. Vehicle and right-of-way characteristics, capacity and operating strategies. Public transportation system performance. Advanced public transportation systems.
- Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin.

Why study Transportation Studies at NJIT?

Transportation planning in the United States is in the midst of a shift similar to that taking place in the United Kingdom, away from the singular goal of moving vehicular traffic and towards an approach that takes into consideration the communities and lands which streets, roads, and highways pass through. We need people like you to lead the way.

Prerequisites

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in economics, mathematics, probability and statistics, and computers. Students who lack an appropriate background may be admitted and required to make up deficiencies by taking a program of courses designed in consultation with graduate advisors.

Related Degree Programs

Credential relates in its entirety to NJIT MS in Transportation (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/transportation-ms/) or MS in Civil Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/civil-environmental/civil-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/transportation-studies-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: I Jy Steven Chien (http://directory.njit.edu/PersDetails.aspx?persid=chien)

Electrical and Computer Engineering

Electrical Engineering

The Department of Electrical and Computer Engineering serves the community, the state and the nation by educating engineers, expanding knowledge and developing new tools for solving complex technological problems. The department's graduate programs offer students with backgrounds in electrical engineering or related areas unusual opportunities to specialize in advanced phases of electrical engineering. In addition to more than 30 full-time faculty members devoted to teaching and research, students are taught by adjunct professors from industry who offer specialty courses in their area of expertise and serve on thesis and dissertation committees.

The master's degree programs provide state-of-the-art training at advanced levels in areas of technical specialization, including faculty-supervised research. Students in the doctoral program conduct significant original research in areas of interest to department members. Students also have opportunities to conduct thesis research at industrial sites, hospitals, biomedical engineering facilities, and university centers and departments.

Master of Science in Electrical Engineering

A program for students with an undergraduate degree in engineering who wish either to specialize in an advanced phase of electrical engineering or prepare for a more advanced degree.

Admission Requirements

Applicants are expected to have undergraduate backgrounds in physics, mathematics (through differential equations and vector analysis), electrical networks and devices, electronics, analysis and design methods, transients, electromagnetic fields, and appropriate laboratory work in some of these areas. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550 (213 computer-based). For further information, see the Admissions section in this catalog.

Graduate Certificate Program

A 12-credit graduate certificate in Telecommunications Networking is available as a step toward this degree. See **Graduate Certificates** in the Degree Programs section of this catalog. For further information, call the Associate Vice President of Continuing and Distance Education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Doctor of Philosophy in Electrical Engineering

This is a program for superior students with master's degrees in electrical engineering or allied fields who wish to conduct advanced research in an area of electrical engineering.

Exceptional Candidates with a Bachelor of Science in Electrical Engineering

Highly qualified students with bachelor's degrees in electrical engineering may be accepted directly into the doctoral program. Contact the doctoral program coordinator for further information.

Admission Requirements

Applicants are expected to have a broad background in engineering, mathematics, physics, and computer science. At least half of undergraduate course work should have been in the physical sciences or similar fields. Doctoral students should have majored in electrical engineering or related field, with course work at the master's level in mathematics, physics and/or computer science. In addition, students are expected to be proficient in computer programming. A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is required for admission. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550 (213 computer-based).

Students who lack an appropriate background will be required to take additional courses that cannot be applied as degree credits.

Computer Engineering

Focus on interdisciplinary course work and research provides students enrolled in the M.S. and Ph.D. in Computer Engineering programs with an advanced background in both the hardware and software aspects of computing.

The master's program prepares computer engineers to successfully make the hardware-software design trade-offs inherent to computing today. The rapid development of computer hardware and software in the last decade has created a demand for engineers who are not only knowledgeable in both these areas, but who also understand their interaction. The fields of embedded computer system design and computer networks are based squarely on this knowledge.

The doctoral program is designed for superior students with a master's degree in computer engineering, computer science, electrical engineering, or other related fields, who wish to pursue advanced research in the area of computer engineering. The master's and doctoral programs emphasize computer architecture and systems, computer networking, intelligent systems, microprocessor-based systems, and VLSI system design.

Master of Science in Computer Engineering

This program prepares its graduates to successfully handle problems requiring in-depth knowledge of both computer hardware and software, and more important, their interaction. Students may concentrate in microprocessor-based systems, parallel computing systems, computer networking, VLSI system design, or machine vision systems. All applicants must submit GRE scores. International students must achieve a minimum TOEFL score of 550 (pencil and paper) and (213 computer-based).

Admission Requirements

Applicants are expected to have an undergraduate education in engineering or computer science. Applicants with baccalaureate degrees in areas other than computer engineering may be admitted and required to complete a bridge program. Those with undergraduate degrees in other fields should consult the MSCOE Program Advisor for bridge requirements. Bridge courses do not count toward degree requirements.

Graduate Certificate Program

A 12-credit graduate certificate in Information Assurance is available as a step toward this degree. Please see **Graduate Certificates** in this catalog for further information. For more information about continuing and distance education, please contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; email: cpe@njit.edu.

Doctor of Philosophy in Computer Engineering

This program is intended for superior students with a master's degree in computer engineering, computer science, electrical engineering, or other related fields, who wish to pursue advanced research in computer engineering. The program emphasizes the following areas: computer architecture and systems, computer networking, intelligent systems, microprocessor-based systems, and VLSI systems design.

Admission Requirements

Applicants are expected to have a master's degree in computer engineering, computer science, electrical engineering, or other related fields. Students who lack an appropriate background may be admitted and required to take bridge courses that cannot be applied as degree credits.

Students must demonstrate superior academic background in engineering, mathematics, and physical science; skills in programming; and proficiency in major areas of computer engineering and science. A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is required for admission. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550 (213 computer-based).

Superior undergraduate students may apply to be admitted directly into the Ph.D. program. Such an accelerated program requires a minimum entrance GPA of 3.5 and an interview with the Electrical and Computer Engineering Department Graduate Affairs Committee.

Internet Engineering

The objective of the master of science in internet engineering program is to educate students in the field of internet engineering, with emphasis on computer internetworking and relevant applications.

Admission Requirements

Applicants should have an undergraduate degree in Computer Engineering, Electrical Engineering or other relevant discipline from an accredited institution (or its equivalent). All applicants must submit scores on the Graduate Record Examinations (GRE) verbal, quantitative, and analytical aptitude tests. International students must also achieve a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based). Applicants with undergraduate degrees in computer science, computer engineering or electrical engineering from an accredited institution are expected to have a GPA of at least 3.0 on a 4.0 scale. These students should have taken ECE 321 Random Signals and Noise), or another equivalent course; ECE 333 Signals and Systems; and proficiency in C++ programming.

Power and Energy Systems (PES)

The master of science in power and energy systems is a program for students with an undergraduate degree in engineering who wish either to specialize in an advanced phase of electrical power engineering and energy systems to prepare for a more advanced degree.

Admission Requirements

Applicants are expected to have undergraduate backgrounds in physics, mathematics (through differential equations and vector analysis), electrical networks and devices, electronics, analysis and design methods, transients, electromagnetic fields, and appropriate laboratory work in some of these areas. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 79 out 120 (or 550 in the old score system). For further information, see the **Admissions** section in this catalog.

Graduate Certificate Program

A 12-credit graduate certificate in Power and Energy Systems is available and can be taken as a step toward this degree. See **Graduate Certificates** in the Degree Programs section of this catalog. For further information, call the Associate Vice President of Continuing and Distance Education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu.

Telecommunications

Telecommunications is one of the most rapidly growing fields in engineering. Telecommunications specialization also is rapidly becoming necessary in such diverse fields as banking, reservation systems, office information systems, corporate networks, and the Internet. Rapid technological progress in gigabit optical networks, multimedia communications, and wireless network access, make the future of the field very exciting.

Master of Science in Telecommunications

The objective of this program is to educate individuals in one or more telecommunication specializations.

Admission Requirements

Applicants are expected to have an undergraduate degree in computer science, computer engineering or electrical engineering from an accredited institution (or its equivalent) with a minimum GPA of 3.0 on a 4.0 scale. These students should have taken CS 333 Introduction to UNIX Operating Systems, ECE 321 Random Signals and Noise and ECE 333 Signals and Systems (or their equivalents). Students without this course work will be required to complete a bridge program. Applicants having degrees in other fields may be considered for admission on an individual basis and required to complete a bridge program. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based).

Graduate Certificate Program

A 12-credit graduate certificate in Telecommunications Networking is available as a step toward this degree. See "**Graduate Certificates**" in this catalog. For further information about extension programs and graduate certificates, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

NJIT Faculty

A

Abdi, Ali, Professor

Akansu, Ali N., Professor

Ansari, Nirwan, Professor

B

Bar-Ness, Yeheskel, Distinguished Professor Emeritus

C

Carpinelli, John D., Professor

Carr, William N., Professor Emeritus

Cornely, Roy H., Professor Emeritus

D

Dhawan, Atam P., Distinguished Professor

F

Feknous, Mohammed, University Lecturer

Frank, Joseph Associate Professor Emeritus

Friedland, Bernard, Distinguished Professor

G

Ge, Hongya, Associate Professor

Grebel, Haim, Professor

H

Haddad, Richard A., Professor Emeritus

Haimovich, Alexander M., Professor

Hou, Sui-Hoi Edwin, Associate Professor

Hubbi, Walid, Associate Professor

K

Kam, Moshe, Professor and Dean of NCE

Khreishah, Abdallah, Assistant Professor

Klapper, Jacob, Professor Emeritus

Kliewer, Joerg, Associate Professor

Ko, Dong-Kyun, Assistant Professor

L

Levkov, Serhiy P., University Lecturer

Liu, Qing, Assistant Professor

Liu, Xuan, Assistant Professor

M

Manzhura, Oksana Yu, University Lecturer

Meyer, Andrew U., Professor Emeritus

Misra, Durgamadhab, Professor

N

Nguyen, Hieu, Assistant Professor

Niver, Edip, Professor

R

Raj, Ratna, University Lecturer

Rojas-Cessa, Roberto, Associate Professor

Rosenstark, Solomon, Professor Emeritus

S

Savir, Jacob, Distinguished Professor

Shi, Yun-Qing, Professor

Simeone, Osvaldo, Associate Professor

Sohn, Kenneth S., Professor Emeritus

Sosnowski, Marek, Professor

T

Tsybeskov, Leonid, Professor and Chair

W

Wang, Cong, Assistant Professor

Whitman, Gerald, Professor

Z

Zhou, Mengchu, Distinguished Professor

Ziavras, Sotirios G., Professor

Programs

- Computer Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/computer-ms/)
- Electrical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/electrical-ms/)
- Internet Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/internet-ms/)
- Power and Energy Systems - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/power-energy-systems-ms/)

- Telecommunications - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/telecommunications-ms/)

Programs

- Computer Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/computer-phd/)
- Electrical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/electrical-phd/)

Programs

- Power Systems Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/power-systems-engineering-cert/)

Electrical and Computer Engineering Courses

ECE 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from Department of Electrical and Computer Engineering and Division of Career Development Services. Cooperative education/internship providing on-the-job reinforcement of academic programs in electrical and computer engineering. Assignments and projects are developed by the co-op office in consultation with the electrical and computer engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in the ECE department. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisites: ECE 590 and permission from Department of Electrical and Computer Engineering and Division of Career Development Services. See ECE 590 course description. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: graduate standing and permission from Department of Electrical and Computer Engineering and Division of Career Development Services. See ECE 590 course description. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

ECE 601. Linear Systems. 3 credits, 3 contact hours.
Methods of linear-system analysis, in both time and frequency domains, are studied. Techniques used in the study of continuous and discrete systems include state-variable representation, matrices, Fourier transforms, LaPlace transforms, inversion theorems, sampling theory, discrete and fast Fourier transforms, and Z-transforms. Computer simulation of linear systems is used, and, where feasible, computer solutions are obtained.

ECE 605. Discrete Event Dynamic Systems. 3 credits, 3 contact hours.
Corequisite: MATH 630 or ECE 601 or MNE 603 or equivalent. Covers the theory of discrete event dynamic systems with applications in modeling, control, analysis, validation, simulation, and performance evaluation of computer systems, flexible manufacturing systems, robotic systems, intelligent supervisory control systems, and communication networks. Emphasis on Petri net and automation based approaches.

ECE 610. Power System Steady-State Analysis. 3 credits, 3 contact hours.
Prerequisite: B.S. in EE or ME. Steady-state analysis of power system networks, particularly real and reactive power flows under normal conditions and current flows under faulty conditions. Symmetrical components and digital solutions are emphasized.

ECE 611. Transients in Power Systems. 3 credits, 3 contact hours.
Prerequisite: ECE 610. Transient performance of power systems with lumped properties, interruption of arcs, restriking voltage, re-ignition inertia effects, switching of rotational systems, magnetic saturation in stationary networks, harmonic oscillations, saturated systems, transient performance of synchronous machines.

ECE 612. Computer Methods Applied to Power Systems. 3 credits, 3 contact hours.
Prerequisite: undergraduate computer programming. Digital computer techniques proven successful in the solution of power system problems, particularly in the electric utility industry. Emphasis on short-circuit, load flow, and transient stability problems. Matrix sparsity is considered.

ECE 613. Protection of Power Systems. 3 credits, 3 contact hours.
Prerequisite: ECE 610 or equivalent Coils, condensers, and resistors as protective devices; fundamental principles of protective relaying; relay operating characteristics; power and current directional relays; differential relays; distance and wire pilot relays; heating and harmonic effects; and Computer-based protective device coordination.

ECE 616. Power Electronics. 3 credits, 3 contact hours.
Prerequisite: B.S. in electrical engineering. Principles of thyristor devices, dynamic characteristics of choppers, commutation, protection, voltage-fed and current-fed inverter drives, cycloconverters, pulse width modulation, phase control, and microcomputer control, with case studies.

ECE 617. Economic Control of Interconnected Power Systems. 3 credits, 3 contact hours.
Economic Control of Interconnected Power Systems: Advanced techniques for operating power systems in the most economic manner while meeting various network constraints; economic dispatch, penalty factors, optimal power flow, short-term electricity markets and locational marginal prices will be studied.

ECE 618. Renewable Energy Systems. 3 credits, 3 contact hours.
This course introduces renewable energy systems. It covers the fundamental concepts of energy and radiation with specific solar energy applications and photovoltaics, electrical energy storage systems, and thermal energy and storage. The second part covers the basic science of wind energy systems and their electrical sytem designs. The third part covers the bioenergy systems from resources to final products and conversion technologies. It finally introduces other promising energy sources.

ECE 620. Electromagnetic Field Theory. 3 credits, 3 contact hours.
Prerequisite: undergraduate electromagnetic field theory or equivalent. Maxwell's equations, boundary conditions and formulation of potentials. LaPlace and Poisson equations for electrostatic and magnetostatic problems and the method of images. Dielectric and magnetic materials, force and energy concepts. Quasi-static and time varying fields, plane, cylindrical and spherical waves. Green's functions, transmission lines.

ECE 622. Wave Propagation. 3 credits, 3 contact hours.
Prerequisite: ECE 620 or equivalent. Fundamentals of electromagnetics; radiation and scattering; Green's functions; integral equations; numerical methods; ray optics and asymptotics.

ECE 624. Optical Engineering. 3 credits, 3 contact hours.
This course covers basic optical concepts, emphasizing those common to many optical instruments, such as light sources and their characteristics, polarization, coherence, and interferometry. The course introduces CAD tools for lenses, optical filters, and instrument design. The course also focuses on topics concerning optical systems, such as flat panel displays and micromechanical optical systems.

ECE 625. Fiber and Integrated Optics. 3 credits, 3 contact hours.
Prerequisite: undergraduate electromagnetic field theory and solid-state circuits. Planar dielectric waveguides, step and graded index fibers and dispersion in fibers. The p-n junction and heterostructures, light emitting diodes and semiconductor lasers, p-i-n and avalanche photodetectors, optical transmitter and receiver designs, optical fiber communication system design concepts.

ECE 626. Optoelectronics. 3 credits, 3 contact hours.
Prerequisite: undergraduate electromagnetic field theory and solid-state circuits. Optical propagation in anisotropic materials, polarization, birefringence and periodic media. Concepts of electro-optics and acousto-optic devices, optical modulators, switches, active filters for optical communication and optical processing.

ECE 630. Microwave Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electromagnetic field theory. Review of transmission line theory and the Smith chart; scattering matrix representation, LC and microstrip matching networks; signal flow graph analysis; micro-wave transistor amplifier design, which includes power gain, stability, noise figure circles; oscillator design.

ECE 632. Antenna Theory. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electromagnetic field theory. Fundamentals of electromagnetic field theory; far field approximation, antenna characteristics (gain, impedance, pattern, etc.); elementary antenna types (dipoles, loops, etc.), antenna array theory, wire antennas; broadband antennas.

ECE 636. Computer Networking Laboratory. 3 credits, 3 contact hours.
Prerequisites: ECE 637 or CS 656. This course provides students with hands on training regarding the design, troubleshooting, modeling and evaluation of computer networks. In this course, students are going to experiment in a real test-bed networking environment, and learn about network design and troubleshooting topics and tools such as: network addressing, Address Resolution Protocol (ARP), basic troubleshooting tools (e.g. ping, ICMP), IP routing (e,g, RIP), route discovery (e.g. traceroute), TCP and UDP, IP fragmentation and many others. Student will also be introduced to the network modeling and simulation, and they will have the opportunity to build some simple networking models using the OPNET modeling tool and perform simulations that will help them evaluate their design approaches and expected network performance.

ECE 637. Internet and Higher-Layer Protocols. 3 credits, 3 contact hours.
The course introduces the protocols and standards of the TCP/IP suite that govern the functioning of the Internet. The material covered in class is a top-down approach on introduction, discussion, and analysis of protocols from the data-link layer to the application layer. Alternative protocols to the TCP/IP suite and new protocols adopted by this suite are discussed. Numerical examples related to network planning and proocol functioning are analyzed.

ECE 638. Network Management and Security. 3 credits, 3 contact hours.
Prerequisites: ECE 683 or CS 652, and ECE 637 or CS 656. Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and from protecting systems for network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms), Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). Same as CIS 696.

ECE 639. Principles of Broadband Networks. 3 credits, 3 contact hours.
Prerequisites: ECE 673, ECE 683 or CS 652 or equivalent. This course covers fundamental concepts of broadband networks. Topics include Broadband ISDN, Switching Techniques, ATM, SONET/SDH, Congestion Control, High-Speed Switching Architectures, Traffic Modeling of Broadband Services, Admission Control, Traffic Scheduling, IP/ATM Convergence, QoS Provisioning in IP Networks, and Optical Networks.

ECE 640. Digital Signal Processing. 3 credits, 3 contact hours.
Prerequisite: ECE 601 or equivalent. The theory of digital signals and basic processing techniques: Discrete Fourier Series, Discrete Fourier Transform and FFT, Linear and Circular Convolution, Digital Filter Design Techniques, Discrete Hilbert Transforms, Discrete Random Signals, Chirp-Z and other advanced transforms. Introduction to multivariate signal processing. The typical applications of signal processing tools are discussed and connected to the theoretical foundations.

ECE 641. Laboratory for High Performance Digital Signal Processing. 3 credits, 3 contact hours.

ECE 642. Communication Systems I. 3 credits, 3 contact hours.
Corequisite: ECE 673. Principles of communication theory applied to the representation and transmission of information. Topics include analysis of deterministic and random signals, amplitude modulation, angle modulation, sampling, quantization, PCM, DM, DPCM, geometric representation of signals, error probability, matched filter and correlation receivers and performance analysis of communication systems signal to noise ratio.

ECE 643. Digital Image Processing I. 3 credits, 3 contact hours.
Prerequisite: ECE 601. Introductory course in digital image processing. Topics include image models, digitization and quantization, image enhancement in spatial and frequency domains, image restoration, image segmentation and analysis.

ECE 644. Wireless Communication. 3 credits, 3 contact hours.
Prerequisites: ECE 321 or MATH 333. This course is focused on the technical challenges and solutions to physical and link layer design of wireless communication systems. Course topics include characterization of the wireless channel, the cellular concept, digital modulation techniques, spread spectrum, multiple access techniques including CDMA and OFDMA, diversity techniques. Advanced techniques such as MIMO, 3G and 4G wireless technologies are introduced. Matlab is used for examples and assignments. Team projects based on advanced wireless technologies.

ECE 645. Wireless Networks. 3 credits, 3 contact hours.
Prerequisites: EE 321 or MATH 333, or equivalent (see undergraduate catalog for descriptions). Introduction to wireless network design, management, and planning stages. Topics include demand modeling, radio planning, network optimization, and information handling architecture with emphasis on resource allocation and mobility management aspects. Investigation of signaling load optimizations and internetworking problems.

ECE 650. Electronic Circuits. 3 credits, 3 contact hours.
Prerequisite: senior undergraduate level semiconductor circuits. Methods of analysis and design of linear and digital semiconductor circuits are studied. Topics include low and high frequency models, passive and active biasing techniques, I-C analysis and design, op-amp circuits, and active filters.

ECE 653. Micro/Nanotechnologies for Interacing Live Cells. 3 credits, 3 contact hours.
In this course, we will study technologies and tools available for interfacing live cells from a sub-cellular, single-cell, and multi-cellular (tissue models) approach. We will introduce key concepts of the biology of cells and tissues and will explore the technologies (micro-/nanotechnologies) and tools (sensors and actuators) available for the investigation of cell and tissue biology. Same as BME 653.

ECE 657. Semiconductor Devices. 3 credits, 3 contact hours.
Fundamental principles of solid state materials necessary for understanding semiconductor devices. Topics include crystal structure; energy bands; electron and hole generation, and transport phenomena; generation and recombination processes, and high field effects. P-N junction diode, metal semiconductor contact, and bipolar and metal oxide semiconductor transistors, including switching phenomena and circuit models. Introduction to: photonic devices~light emitting diodes, semiconductor lasers, photodetectors, and solar cells; microwave devices~tunnel and IMPATT diodes, transferred electron devices, and charge-coupled capacitors.

ECE 658. VLSI Design I. 3 credits, 3 contact hours.
Prerequisite: ECE 657 or equivalent. Analysis and design of digital integrated circuits; basic building blocks and dependence on circuit parameters of propagation delay; noise margin; fan-out; fan-in; and power dissipation for circuits of different logic families, including NMOS, CMOS and BiCMOS; subsystem designs in combinational and sequential logic; Memory Systems; HSPICE circuit simulation is used for digital characteristics evaluation. Mentor Graphics Layout design tools are used for chip design.

ECE 659. Fabrication Principles of Electronic and Optoelectronic Devices. 3 credits, 3 contact hours.
Prerequisite: ECE 657 or equivalent. Overview of all major processing steps in fabrication of integrated circuits such as crystal growth, epitaxy, oxidation, diffusion, ion implantation and etching. Formation of thin film structures along with techniques for defining submicron structures. Emphasizes silicon device technology but also includes processing of compound semiconductors such as gallium arsenide.

ECE 660. Control Systems I. 3 credits, 3 contact hours.
Prerequisites: undergraduate course equivalent to EE 333 or ME 305 (see undergraduate catalog for descriptions) and ECE 601 or equivalent or permission from instructor. Introduction to feedback control. Review of state-space analysis. Frequency-domain methods for analysis: Routh-Hurwitz stability algorithms, Root-loci; Nyquist and Bode plots; system ?type.? Controllability and observability. The separation principle and design by pole placement. Linear observers. Optimization of quadratic performance criteria. Elements of random processes. The Kalman filter as an optimum observer. Robustness considerations.

ECE 661. Control System Components. 3 credits, 3 contact hours.
Prerequisite: ECE 660. The theoretical and practical requirements for analog and digital state-of-the-art control system components are covered. Actuators, amplifiers, sensors, encoders, resolvers and other electromagnetic devices are included. A complete system is designed using current vendor catalog data. Problems affecting the system performance are analyzed using measures of functionality, reliability and cost.

ECE 664. Real-time Computer Control Systems. 3 credits, 3 contact hours.
Prerequisite: EE 486 or equivalent (see undergraduate catalog for description). Emphasizes the practical aspects of modern computer control systems. Topics include: Architecture of digital signal processors (DSP) and microcontrollers, real-time data acquisition devices and interface, programming a DSP, review of sampling theorems and properties of discrete-time systems, introduction of control systems theory, design and implementation of parameter optimized controllers, state variable controllers, and cancellation controllers. An experimental project using a TMS320C2x DSP-based data acquisition system is an integral part of this course.

ECE 667. Bio-Control Systems. 3 credits, 3 contact hours.
The course provides an introduction to dynamic and control in biological systems, with particular emphasis on engineering aspects of biological oscillators/waves which govern the basic operations of all living organisms and especially higher order life forms. A combination of theoretical and simulation tools will be applied to analyze the qualitative and quantitative properties of selected biological systems. Feedback and control mechanisms in selected biological systems will be introduced. Same as BME 667.

ECE 673. Random Signal Analysis I. 3 credits, 3 contact hours.
Fundamentals of the theory of random variables. Introduction to the theory of random processes. Topics include functions of random variables, sequences of random variables, central limit theorem, properties of random processes, correlation, spectral analysis and linear systems with random inputs.

ECE 681. High Performance Routers and Switches. 3 credits, 3 contact hours.
The course introduces the different system comprising and Internet routing including the processors for networking function and protocol compliance, switching functions and packet classification for deep-layer inspection capable routers or network appliances. This course material describe the different functions that Internet routers perform and discusses the different approaches used for improving performance of high-end routers. The content includes a discussion on switch architectures.

ECE 683. Computer Network Design and Analysis. 3 credits, 3 contact hours.
Corequisite: ECE 673. Queueing models and state-transition models are introduced to model, design and analyze computer networks. The OSI model, LANS (including token ring, token bus, and Ethernet), and useful network protocols. Emphasis on the physical, data link and network layers. ALOHA, Stop-and-Wait protocol, Go-Back-N protocol, window-flow-control, and shortest-path routing.

ECE 684. Advanced Microprocessor Systems. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in computer architecture and microprocessors, and some experience in assembly language programming. Architecture of advanced microprocessors; CPU architecture, memory management and protection, interrupt and exception facilities, instruction sets, systems aspects including peripheral interfaces, communications ports, and real-time systems.

ECE 689. Computer Arithmetic Algorithms. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in logic design. Data representation, integers, floating point and residue representation. Bounds on arithmetic speed, algorithms for high speed addition, multiplication, and division. Pipelined arithmetic. Hardware implementation and control issues.

ECE 690. Computer Systems Architecture. 3 credits, 3 contact hours.
Prerequisites: ECE 684 and COE 353 (see undergraduate catalog for description) or CS 650. Discusses advanced topics in modern computer systems architecture such as pipelined and superscalar processors, parallel computers (vector, SIMD, MIMD), multithreaded and dataflow architectures, cache and memory hierarchy, and system interconnect architectures. Also discusses relevant system software design issues such as shared memory and message-passing communication models, cache coherence and synchronization mechanisms, latency-hiding techniques, virtual memory management, program partitioning and scheduling. Examples are drawn from real systems.

ECE 692. Embedded Computing Systems. 3 credits, 3 contact hours.
Pre-requisites: ECE 353 (COE) or ECE 684 (EE) and CS 105 (or equivalents). Introduction of the methodology for the design and implementation of embedded computing systems, and its application to real-world problems. Topics include Embedded System Design Process, UML, ARM Instruct Set Architectures, CPU's Hardware Platforms, Software Design and Analysis, Embedded Operating Systems, Real-Time Scheduling, Hardware Accelerators, Distributed Embedded Systems, and Design Methodology and Quality Assurance.

ECE 698. Selected Topics in Electrical and Computer Engineering. 3 credits, 3 contact hours.
Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

ECE 699. Selected Topics in Electrical and Computer Engineering II. 3 credits, 3 contact hours.
See description for ECE 698 above.

ECE 700. Master's Project. 0 credits, 0 contact hours.
Prerequisite: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry may be acceptable. Work is carried out under the supervision of a member of the department faculty. A maximum of 3 credits may be applied to the degree.

ECE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. A written report must be submitted to the project advisor. The student cannot register in ECE 700B more than once and the incomplete (I) grade is not allowed.

ECE 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: written approval of thesis advisor. Projects involving design, construction, experimental or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried on under the supervision of a designated member of the department faculty. Completed work in the form of a written thesis should be of a quality leading to journal publication. The completed thesis must be defended by the student in an open forum and must be approved by a committee of at least three people. A student must register for a minimum of 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

ECE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in ECE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ECE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (ECE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ECE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

ECE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for ECE 726 if they have taken ECE 725 in a prior semester.

ECE 739. Laser Systems. 3 credits, 3 contact hours.
Prerequisite: ECE 620 or permission of instructor. Optical resonators, laser radiation and oscillation. Laser characteristics: semiconductor lasers, gas and glass lasers; mode-locking, Q-switching. Quantum-well lasers, noise; modulation and detection of laser light, optical systems for communication and computation.

ECE 740. Advanced Digital Signal Processing. 3 credits, 3 contact hours.
Prerequisites: ECE 601, ECE 640 and ECE 673. Topics in stationary discrete time stochastic processes; modeling of discrete time processes, Yule-waker equations, aspects of discrete wiener theory; principle of orthogonality, linear predictors; Levinson-Durbin recursion and algorithm, lattice predictors, method of least squares (RLS) algorithm, systolic array implementation of QRD-Ls.

ECE 742. Communication Systems II. 3 credits, 3 contact hours.
Prerequisites: ECE 642 and ECE 673 or equivalents. Principles of digital communication. Topics include fundamentals of information theory, digital modulation techniques, optimum detector receivers for digitally modulated signals, the bandlimited gaussian channel and intersymbol interference, equalization, spread spectrum, CDMA.

ECE 743. Image Data Hiding, Forensics. 3 credits, 3 contact hours.
Prerequisites: ECE 643 or CS 659 or equivalent As we have entered digital world, information forensics and security have become critically important. With digital images as media, this course covers digital watermarking, reversible data hiding, steganography and steganalysis, forensics and counter-forensics, including image tampering detection, classification of double JPEG/MPEG compressions, camera classification from given images, classification of photographic images from computer graphic images, and so on.

ECE 744. Optimization for Communication Networks. 3 credits, 3 contact hours.
Modern communication are required to provide optimal performance in terms of quality-of-service under strict constrains on the utilization of resources, such as spectrum of power. In addition, the emerging paradigm of decentralized communication systems, such as ad hoc and sensor networks, calls for distributed, and possibly competitive, optimization techniques. This course covers the basic analytical and algorithmic tools that enable such centralized and decentralized optimization.

ECE 747. Signal Decomposition Techniques: Transforms, Sub-bands, and Wavelets. 3 credits, 3 contact hours.
Prerequisites: ECE 640 and ECE 673. Multiresolution signal decomposition techniques, transforms, sub-bands, and wavelets. Time-frequency localization properties of multiresolution algorithms. Evaluation and critique of proposed decomposition strategies from compression and performance standpoints. Applications to speech and video compression, and localized feature extraction. These are basic signal processing tools used in diverse applications such as speech and image processing and storage, seismology, machine vision.

ECE 754. Statistical Machine Learning and Pattern Recognition. 3 credits, 3 contact hours.
Prerequisites: Good knowledge of graduate probability, as in ECE 673 or equivalent, and linear algebra; or permission of instructor. This course provides a systematic introduction to machine learning and pattern recognition using information-theoretic performance criteria as guiding principles. Topics covered include linear and kernel models for classification and regression, sample complexity and VC dimension, probabilistic graphical models and approximate inference.

ECE 755. Advanced Topics in Digital Communications. 3 credits, 3 contact hours.
Prerequisites: ECE 642 and ECE 673 or equivalent. Advanced topics in digital communication systems in the presence of intersymbol interference, noise, and fading: modulation and demodulation in the presence of gaussian noise, efficient signaling with coded modulation, trellis decoding, Viterbi algorithm, digital transmission with intersymbol interference, and digital signaling over imperfect channels.

ECE 756. Advanced Topics in Semiconductor Devices. 3 credits, 3 contact hours.
Prerequisite: ECE 657 or permission of instructor. Builds on ECE 657. Covers photonic devices particularly semiconductor laser and photodetectors for optical systems; microwave and other high speed devices; scaled advanced MOS, FET, and bipolar transistors.

ECE 758. VLSI Design II. 3 credits, 3 contact hours.
Prerequisite: ECE 658 (with ECE 657 suggested). Use of CMOS, biCMOS and bipolar semiconductor technology for VLSI design. Digital techniques are emphasized with minor coverage of analog design. Application areas for full custom, gate arrays, standard cell, and compiled designs are compared. Mentor VLSI design tools running on the HP and Sun workstations are used in the course projects for each enrollee. The course attempts to provide a design environment for projects that is similar to that encountered by VLSI designers in industry.

ECE 760. Solid-State Image Sensors. 3 credits, 3 contact hours.
Prerequisites: ECE 601 and ECE 660. Properties of nonlinear systems and basic concepts of stability including small-signal linearization. State plane methods are introduced, with emphasis on controller design for systems that can be represented by second-order approximations. Concepts of equivalent gain, describing function, and dual-input describing function as applied to a large class of nonlinear systems. Representation of linear sampled-data systems in discrete state variable form, stability and performance of discrete-event systems. Full-state feedback, pole placement and observer design. Linear quadratic control and Kalman filtering.

ECE 776. Information Theory. 3 credits, 3 contact hours.
Prerequisites: ECE 642 and ECE 673 or equivalents. Classical theory of information developed from Shannon's theory. Information measure, Markov sources and extensions, the adjoint source, uniquely decodable and instantaneous codes and their construction, Shannon's first and second theorems, mutual information, and performance bounds on block and convolutional codes.

ECE 777. Statistical Decision Theory in Communications. 3 credits, 3 contact hours.
Prerequisite: ECE 642 or equivalent. Relation between detection theory and statistical hypothesis testing problem. Use of Bayes decision criteria, Neyman-Pearson, and mini-max tests; receiver operating characteristics. Representation of signals in signal space, probability of error calculations. Estimation of random and non-random signal parameters, Cramer-Rao Inequality. The general Gaussian problem and the use of covariance matrices.

ECE 783. Computer Communication Networks. 3 credits, 3 contact hours.
Prerequisites: ECE 673 and ECE 683. Data link control and communication channels. Delay models in data networks. Queueing analysis techniques are taught in detail. Multi-access communication techniques. Routing in computer communication networks.

ECE 788. Selected Topics in Electrical and Computer Engineering. 3 credits, 3 contact hours.
Special-area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

ECE 789. Selected Topics in Electrical and Computer Engineering II. 3 credits, 3 contact hours.
See description for ECE 788.

ECE 790. Doctrl Dissrtn & Research. 0 credits, 0 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790A. Doctrl Dissrtn & Research. 1 credit, 1 contact hour.
Co-requisite: ECE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in ECE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

ECE 790B. Doctrl Dissrtn & Research. 3 credits, 3 contact hours.
Co-requisite: ECE 791. Since the ECE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

ECE 790C. Doctrl Dissertation & Resrch. 6 credits, 6 contact hours.
Co-requisite: ECE 791. Since the ECE 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

ECE 790D. Doctrl Dissertation & Resrch. 9 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790E. Doct Dissrtation & Resrch. 12 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790F. Doct Dissertation & Resrch. 15 credits, 3 contact hours.
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 790G. Doct Dissertation & Resrch. 18 credits, 3 contact hours.

ECE 791. Graduate Seminar. 0 credits, 0.5 contact hours.
All master's and doctoral students must register for two semesters and six semesters of ECE 791 Graduate Seminar, respectively. To receive a satisfactory grade, students must attend at least five seminars during the semester, as approved by the seminar supervisor.

ECE 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: ECE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in electrical or computer engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ECE 792C. Pre-Doctoral Research. 6 credits, 3 contact hours.

M.S. in Computer Engineering

Degree Requirements

Students must complete 30 credits; 21 or more credits must be from ECE courses. They include two required computer engineering core courses, two more required courses for one of the five areas of specialization, and a master's project or thesis. As a requirement for graduation, students must achieve a 3.0 cumulative GPA, not including the master's thesis or project. The master's thesis or project grade must be B or higher.

M.S. in Computer Engineering (Master's project)

Code	Title	Credits
Bridge Courses (undergraduate degree in computer science)		
ECE 353	Computer Organization and Architecture	3
ECE 395	Microprocessor Laboratory	2
ECE 231	Circuits and Systems I	3
ECE 684	Advanced Microprocessor Systems	3
Total Credits		11

Code	Title	Credits
Bridge Courses (undergraduate degree in electrical engineering)		
CS 505	Programming, Data Structures, and Algorithms	3
or CS 506	Foundations of Computer Science	
ECE 353	Computer Organization and Architecture	3
ECE 395	Microprocessor Laboratory	2

Code	Title	Credits
ECE 684	Advanced Microprocessor Systems	3
Total Credits		11

Code	Title	Credits
Core Courses		
CS 610	Data Structures and Algorithms	3
ECE 690	Computer Systems Architecture	3
Project		
ECE 700	Master's Project	0
Electives		
Select six of the following:		18
Areas of Specialization		
Select two of the following:		6
Computer Architecture and Embedded Systems		
ECE 658	VLSI Design I	
ECE 692	Embedded Computing Systems	
Intelligent Systems		
ECE 605	Discrete Event Dynamic Systems	
VLSI System Design		
ECE 658	VLSI Design I	
ECE 758	VLSI Design II	
Computer Networking		
ECE 683	Computer Network Design and Analysis	
ECE 637	Internet and Higher-Layer Protocols	
or ECE 783	Computer Communication Networks	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Required for one semester.

M.S. in Computer Engineering (Master's thesis)

Code	Title	Credits
Bridge Courses (undergraduate degree in computer science)		
ECE 353	Computer Organization and Architecture	3
ECE 395	Microprocessor Laboratory	2
ECE 231	Circuits and Systems I	3
Total Credits		8

Code	Title	Credits
Bridge Courses (undergraduate degree in electrical engineering)		
CS 505	Programming, Data Structures, and Algorithms	3
or CS 506	Foundations of Computer Science	
ECE 353	Computer Organization and Architecture	3
ECE 395	Microprocessor Laboratory	2
Total Credits		8

Code	Title	Credits
Core Courses		
CS 610	Data Structures and Algorithms	3
ECE 690	Computer Systems Architecture	3
Thesis		
ECE 701B	Master's Thesis	3

Electives		
Select five of the following:		15
Areas of Specialization		
Select two of the following:		6
Computer Architecture and Embedded Systems		
ECE 658	VLSI Design I	
ECE 692	Embedded Computing Systems	
Intelligent Systems		
ECE 605	Discrete Event Dynamic Systems	
VLSI System Design		
ECE 658	VLSI Design I	
ECE 758	VLSI Design II	
Computer Networking		
ECE 683	Computer Network Design and Analysis	
ECE 637	Internet and Higher-Layer Protocols	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Required for one semester.

M.S. in Electrical Engineering

Degree Requirements

Bridge Program

Students who have earned a Bachelor of Science in Engineering Technology (B.S.E.T.) degree, or who lack an appropriate background may be admitted and be required to take selected courses in addition to the degree requirements in order to make up deficiencies. They must attain a grade of B or better in each course. At the discretion of the department, students who have taken courses equivalent to these may have their bridge programs reduced accordingly.

Master's Program

Upon entering the program, students select an area of specialization supervised by the MSEE Program Advisor. The master's program consists of 30 credits. Students who enter the program but who do not receive departmental or research-based awards have three program options: 24 course credits and 6 credits of master's thesis; or 27 course credits and 3 credits of master's project; or 30 course credits not to include either a master's project or thesis. Thesis is required for all those receiving departmental or research-based support. For all others, a project or thesis is optional. Students should consult with the Program Advisor or designee before registering for courses to make sure they are meeting department requirements. As a requirement for graduation, students must achieve a 3.0 cumulative GPA in graduate-level courses, not including the master's thesis or project. The project grade must be B or better.

ECE courses at the 500 level are not acceptable for credit toward a graduate degree in electrical engineering. Only one 500 level course outside the department may be applied for credit toward a graduate degree in electrical engineering.

Areas of Specialization

Entering students must select an area of specialization during their first semester. Special topics courses and electives are chosen with the approval of the MSEE Program Advisor or designee. Two non-ECE graduate courses may be chosen. Students should contact the MSEE Program Advisor for guidance.

Focus Area: Communications, Signal Processing and Microwave (courses only)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3

ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 640	Digital Signal Processing	
ECE 642	Communication Systems I	
ECE 742	Communication Systems II	
ECE 740	Advanced Digital Signal Processing	
ECE 632	Antenna Theory	
Suggested Electrical Engineering Electives		
Select six of the following:		18
ECE 622	Wave Propagation	
ECE 625	Fiber and Integrated Optics	
ECE 626	Optoelectronics	
ECE 642	Communication Systems I	
ECE 644	Wireless Communication	
ECE 684	Advanced Microprocessor Systems	
ECE 747	Signal Decomposition Techniques: Transforms, Sub-bands, and Wavelets	
ECE 755	Advanced Topics in Digital Communications	
ECE 776	Information Theory	
ECE 777	Statistical Decision Theory in Communications	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area: Communications, Signal Processing and Microwave (Master's project)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 640	Digital Signal Processing	
ECE 642	Communication Systems I	

ECE 742	Communication Systems II	
ECE 740	Advanced Digital Signal Processing	
ECE 632	Antenna Theory	
Project		
ECE 700B	Master's Project	3
Suggested Electrical Engineering Electives		
Select five of the following:		15
ECE 622	Wave Propagation	
ECE 625	Fiber and Integrated Optics	
ECE 626	Optoelectronics	
ECE 642	Communication Systems I	
ECE 644	Wireless Communication	
ECE 684	Advanced Microprocessor Systems	
ECE 747	Signal Decomposition Techniques: Transforms, Sub-bands, and Wavelets	
ECE 755	Advanced Topics in Digital Communications	
ECE 776	Information Theory	
ECE 777	Statistical Decision Theory in Communications	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area: Communications, Signal Processing and Microwave (Master's thesis)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 640	Digital Signal Processing	
ECE 642	Communication Systems I	
ECE 742	Communication Systems II	
ECE 740	Advanced Digital Signal Processing	
ECE 632	Antenna Theory	
Thesis		
ECE 701B & 701B	Master's Thesis and Master's Thesis	6
or ECE 701C	Master's Thesis	
Suggested Electrical Engineering Electives		
Select four of the following:		12
ECE 622	Wave Propagation	

ECE 625	Fiber and Integrated Optics	
ECE 626	Optoelectronics	
ECE 642	Communication Systems I	
ECE 644	Wireless Communication	
ECE 684	Advanced Microprocessor Systems	
ECE 747	Signal Decomposition Techniques: Transforms, Sub-bands, and Wavelets	
ECE 755	Advanced Topics in Digital Communications	
ECE 776	Information Theory	
ECE 777	Statistical Decision Theory in Communications	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Computer Networking (courses only)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
ECE 683	Computer Network Design and Analysis	3
ECE 783	Computer Communication Networks	3
Suggested Electrical Engineering Electives		
Select six of the following:		18
ECE 605	Discrete Event Dynamic Systems	
ECE 637	Internet and Higher-Layer Protocols	
ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	
ECE 642	Communication Systems I	
ECE 644	Wireless Communication	
ECE 645	Wireless Networks	
ECE 658	VLSI Design I	
ECE 681	High Performance Routers and Switches	
ECE 690	Computer Systems Architecture	
ECE 742	Communication Systems II	
CS 610	Data Structures and Algorithms	
CS 665	Algorithmic Graph Theory	
MATH 661	Applied Statistics	
MGMT 685	Operations Research and Decision Making	
Seminar		

ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Computer Networking (Master's project)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
ECE 683	Computer Network Design and Analysis	3
ECE 783	Computer Communication Networks	3
Project		
ECE 700B	Master's Project	3
Suggested Electrical Engineering Electives		
Select five of the following:		15
ECE 605	Discrete Event Dynamic Systems	
ECE 637	Internet and Higher-Layer Protocols	
ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	
ECE 642	Communication Systems I	
ECE 644	Wireless Communication	
ECE 645	Wireless Networks	
ECE 658	VLSI Design I	
ECE 681	High Performance Routers and Switches	
ECE 690	Computer Systems Architecture	
ECE 742	Communication Systems II	
ECE 744	Optimization for Communication Networks	
CS 610	Data Structures and Algorithms	
CS 665	Algorithmic Graph Theory	
MATH 661	Applied Statistics	
MGMT 685	Operations Research and Decision Making	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Computer Networking (Master's thesis)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
ECE 683	Computer Network Design and Analysis	3
ECE 783	Computer Communication Networks	3
Thesis		
ECE 701B & 701B	Master's Thesis and Master's Thesis	6
or ECE 701C	Master's Thesis	
Suggested Electrical Engineering Electives		
Select four of the following:		12
ECE 605	Discrete Event Dynamic Systems	
ECE 637	Internet and Higher-Layer Protocols	
ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	
ECE 642	Communication Systems I	
ECE 644	Wireless Communication	
ECE 645	Wireless Networks	
ECE 658	VLSI Design I	
ECE 681	High Performance Routers and Switches	
ECE 690	Computer Systems Architecture	
ECE 742	Communication Systems II	
ECE 744	Optimization for Communication Networks	
CS 610	Data Structures and Algorithms	
CS 665	Algorithmic Graph Theory	
MATH 661	Applied Statistics	
MGMT 685	Operations Research and Decision Making	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Computer Architecture (courses only)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3

Code	Title	Credits
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
ECE 689	Computer Arithmetic Algorithms	3
ECE 690	Computer Systems Architecture	3
Suggested Electrical Engineering Electives		
Select six of the following:		18
ECE 605	Discrete Event Dynamic Systems	
ECE 612	Computer Methods Applied to Power Systems	
ECE 640	Digital Signal Processing	
ECE 643	Digital Image Processing I	
ECE 650	Electronic Circuits	
ECE 660	Control Systems I	
ECE 664	Real-time Computer Control Systems	
ECE 684	Advanced Microprocessor Systems	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Computer Architecture (Master's project)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
ECE 689	Computer Arithmetic Algorithms	3
ECE 690	Computer Systems Architecture	3
Project		
ECE 700B	Master's Project	3
Suggested Electrical Engineering Electives		
Select five of the following:		15
ECE 605	Discrete Event Dynamic Systems	

ECE 612	Computer Methods Applied to Power Systems	
ECE 640	Digital Signal Processing	
ECE 643	Digital Image Processing I	
ECE 650	Electronic Circuits	
ECE 660	Control Systems I	
ECE 664	Real-time Computer Control Systems	
ECE 684	Advanced Microprocessor Systems	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Computer Architecture (Master's thesis)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
ECE 689	Computer Arithmetic Algorithms	3
ECE 690	Computer Systems Architecture	3
Thesis		
ECE 701B & 701B	Master's Thesis and Master's Thesis	6
or ECE 701C	Master's Thesis	
Suggested Electrical Engineering Electives		
Select four of the following:		12
ECE 605	Discrete Event Dynamic Systems	
ECE 612	Computer Methods Applied to Power Systems	
ECE 640	Digital Signal Processing	
ECE 643	Digital Image Processing I	
ECE 650	Electronic Circuits	
ECE 660	Control Systems I	
ECE 664	Real-time Computer Control Systems	
ECE 684	Advanced Microprocessor Systems	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Solid State, VLSI and Electro-optics Systems (courses only)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 622	Wave Propagation	
ECE 626	Optoelectronics	
ECE 650	Electronic Circuits	
ECE 657	Semiconductor Devices	
ECE 658	VLSI Design I	
ECE 758	VLSI Design II	
Suggested Electrical Engineering Electives		
Select six of the following:		18
ECE 605	Discrete Event Dynamic Systems	
ECE 624	Optical Engineering	
ECE 625	Fiber and Integrated Optics	
ECE 630	Microwave Engineering	
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices	
ECE 660	Control Systems I	
ECE 684	Advanced Microprocessor Systems	
ECE 690	Computer Systems Architecture	
ECE 739	Laser Systems	
ECE 756	Advanced Topics in Semiconductor Devices	
ECE 789	Selected Topics in Electrical and Computer Engineering II	
MTSE 702	Characterization of Solids	
MTSE 650	Physical Metallurgy	
MTSE 765	Science and Technology of Thin Films	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Solid State, VLSI and Electro-optics Systems (Master's project)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3

ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 622	Wave Propagation	
ECE 626	Optoelectronics	
ECE 650	Electronic Circuits	
ECE 657	Semiconductor Devices	
ECE 658	VLSI Design I	
ECE 758	VLSI Design II	
Project		
ECE 700B	Master's Project	3
Suggested Electrical Engineering Electives		
Select five of the following:		15
ECE 605	Discrete Event Dynamic Systems	
ECE 624	Optical Engineering	
ECE 625	Fiber and Integrated Optics	
ECE 630	Microwave Engineering	
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices	
ECE 660	Control Systems I	
ECE 684	Advanced Microprocessor Systems	
ECE 690	Computer Systems Architecture	
ECE 739	Laser Systems	
ECE 756	Advanced Topics in Semiconductor Devices	
ECE 789	Selected Topics in Electrical and Computer Engineering II	
MTSE 702	Characterization of Solids	
MTSE 650	Physical Metallurgy	
MTSE 765	Science and Technology of Thin Films	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Solid State, VLSI and Electro-optics Systems (Master's thesis)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 622	Wave Propagation	
ECE 626	Optoelectronics	
ECE 650	Electronic Circuits	
ECE 657	Semiconductor Devices	
ECE 658	VLSI Design I	
ECE 758	VLSI Design II	
Thesis		
ECE 701B & 701B	Master's Thesis and Master's Thesis	6
or ECE 701C	Master's Thesis	
Suggested Electrical Engineering Electives		
Select four of the following:		12
ECE 605	Discrete Event Dynamic Systems	
ECE 624	Optical Engineering	
ECE 625	Fiber and Integrated Optics	
ECE 630	Microwave Engineering	
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices	
ECE 660	Control Systems I	
ECE 684	Advanced Microprocessor Systems	
ECE 690	Computer Systems Architecture	
ECE 739	Laser Systems	
ECE 756	Advanced Topics in Semiconductor Devices	
ECE 789	Selected Topics in Electrical and Computer Engineering II	
MTSE 702	Characterization of Solids	
MTSE 650	Physical Metallurgy	
MTSE 765	Science and Technology of Thin Films	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Intelligent Systems (courses only)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3

ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 605	Discrete Event Dynamic Systems	
ECE 610	Power System Steady-State Analysis	
ECE 660	Control Systems I	
Suggested Electrical Engineering Electives		
Select six of the following:		18
ECE 611	Transients in Power Systems	
ECE 613	Protection of Power Systems	
ECE 616	Power Electronics	
ECE 617	Economic Control of Interconnected Power Systems	
ECE 640	Digital Signal Processing	
ECE 664	Real-time Computer Control Systems	
ECE 661	Control System Components	
ECE 684	Advanced Microprocessor Systems	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Intelligent Systems (Master's project)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 605	Discrete Event Dynamic Systems	
ECE 610	Power System Steady-State Analysis	
ECE 660	Control Systems I	
Project		
ECE 700B	Master's Project	3
Suggested Electrical Engineering Electives		
Select five of the following:		15
ECE 611	Transients in Power Systems	
ECE 613	Protection of Power Systems	
ECE 616	Power Electronics	
ECE 617	Economic Control of Interconnected Power Systems	
ECE 640	Digital Signal Processing	

ECE 664	Real-time Computer Control Systems	
ECE 661	Control System Components	
ECE 684	Advanced Microprocessor Systems	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

Focus Area : Intelligent Systems (Master's thesis)

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 361	Electromagnetic Fields I	3
ECE 362	Electromagnetic Fields II	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
or ECE 620	Electromagnetic Field Theory	
Area Requirements		
Select two of the following:		6
ECE 605	Discrete Event Dynamic Systems	
ECE 610	Power System Steady-State Analysis	
ECE 660	Control Systems I	
Thesis		
ECE 701B & 701B	Master's Thesis and Master's Thesis	6
or ECE 701C	Master's Thesis	
Suggested Electrical Engineering Electives		
Select four of the following:		12
ECE 611	Transients in Power Systems	
ECE 613	Protection of Power Systems	
ECE 616	Power Electronics	
ECE 617	Economic Control of Interconnected Power Systems	
ECE 640	Digital Signal Processing	
ECE 664	Real-time Computer Control Systems	
ECE 661	Control System Components	
ECE 684	Advanced Microprocessor Systems	
Seminar		
ECE 791	Graduate Seminar [1]	0
Total Credits		30

[1] Two semesters are required.

M.S. in Internet Engineering

Degree Requirements

The bridge program curriculum requires a basic knowledge of computer and communications fundamentals.

All master's degree candidates must complete a minimum of 30 credits, 9 in core courses and 21 in elective courses; or 21 credits must be from ECE courses.

The required courses provide the basics of Internet Engineering. Electives are to be chosen from the available course pool to tailor the program to the student's professional needs and interests. This program utilizes graduate courses in Electrical and Computer Engineering, Computer and Information Science, Management Information Systems, and Management Programs at NJIT. They provide the necessary blend of education required for appropriate strength in Internet Engineering.

M.S. in Internet Engineering (courses only)

Code	Title	Credits
Bridge Courses [1]		
ECE 333	Signals and Systems	3
ECE 481	Digital Communications Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
ECE 251	Digital Design	3
Total Credits		12

1 Bridge courses are usually selected from this list, but some additional bridge courses, appropriate to each student's background, may be required.

Code	Title	Credits
Core Courses		
ECE 637	Internet and Higher-Layer Protocols	3
ECE 683	Computer Network Design and Analysis	3
CS 602	Java Programming	3
Electives [1]		
Select seven of the following:		21
ECE 673	Random Signal Analysis I	
ECE 681	High Performance Routers and Switches	
ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	
ECE 645	Wireless Networks	
ECE 636	Computer Networking Laboratory	
MGMT 620	Management of Technology	
MIS 625	Management Strategies for E-Commerce	
ECE 783	Computer Communication Networks	
ECE 788	Selected Topics in Electrical and Computer Engineering	
or ECE 789	Selected Topics in Electrical and Computer Engineering II	
Seminar		
ECE 791	Graduate Seminar [2]	0
Total Credits		30

1 Other (new) courses related to Internet Engineering may be selected as electives with approval from the Graduate Advisor

2 Two semesters are required.

M.S. in Internet Engineering (Master's project)

Code	Title	Credits
Bridge Courses [1]		
ECE 333	Signals and Systems	3

ECE 481	Digital Communications Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
ECE 251	Digital Design	3
Total Credits		12

1 Bridge courses are usually selected from this list, but some additional bridge courses, appropriate to each student's background, may be required.

Code	Title	Credits
Core Courses		
ECE 637	Internet and Higher-Layer Protocols	3
ECE 683	Computer Network Design and Analysis	3
CS 602	Java Programming	3
Project		
ECE 700B	Master's Project	3
Electives [1]		
Select six of the following:		18
ECE 673	Random Signal Analysis I	
ECE 681	High Performance Routers and Switches	
ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	
ECE 645	Wireless Networks	
ECE 636	Computer Networking Laboratory	
MGMT 620	Management of Technology	
MIS 625	Management Strategies for E-Commerce	
ECE 783	Computer Communication Networks	
ECE 788	Selected Topics in Electrical and Computer Engineering	
or ECE 789	Selected Topics in Electrical and Computer Engineering II	
Seminar		
ECE 791	Graduate Seminar [2]	0
Total Credits		30

1 Other (new) courses related to Internet Engineering may be selected as electives with approval from the Graduate Advisor

2 Two semesters are required.

M.S. in Internet Engineering (Master's thesis)

Code	Title	Credits
Bridge Courses [1]		
ECE 333	Signals and Systems	3
ECE 481	Digital Communications Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
ECE 251	Digital Design	3
Total Credits		12

1 Bridge courses are usually selected from this list, but some additional bridge courses, appropriate to each student's background, may be required.

Code	Title	Credits
Core Courses		
ECE 637	Internet and Higher-Layer Protocols	3
ECE 683	Computer Network Design and Analysis	3
CS 602	Java Programming	3
Thesis		

ECE 701B & 701B	Master's Thesis and Master's Thesis	6
or ECE 701C	Master's Thesis	
Electives [1]		
Select five of the following:		15
ECE 673	Random Signal Analysis I	
ECE 681	High Performance Routers and Switches	
ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	
ECE 645	Wireless Networks	
ECE 636	Computer Networking Laboratory	
MGMT 620	Management of Technology	
MIS 625	Management Strategies for E-Commerce	
ECE 783	Computer Communication Networks	
ECE 788	Selected Topics in Electrical and Computer Engineering	
or ECE 789	Selected Topics in Electrical and Computer Engineering II	
Seminar		
ECE 791	Graduate Seminar [2]	0
Total Credits		30

[1] Other (new) courses related to Internet Engineering may be selected as electives with approval from the Graduate Advisor

[2] Two semesters are required.

M.S. in Power and Energy Systems

Degree Requirements

Bridge Program

Students who have earned a Bachelor of Science in Engineering Technology (B.S.E.T.) degree, or who lack an appropriate background may be admitted and be required to take selected courses in addition to the degree requirements in order to make up deficiencies. They must attain a grade of B or better in each course. At the discretion of the department, students who have taken courses equivalent to these may have their bridge programs reduced accordingly.

Master's Program

This master's program consists of 30 credits. As a requirement for graduation, students must achieve a 3.0 cumulative GPA in graduate-level courses, not including the master's thesis or project. The project grade must be B or better.

Master's Project/Master's Thesis

If you do a Master’s Project, you need to take in total 9 courses plus ECE 700 Master's Project; and if you do a Master’s thesis, you need to take 8 courses plus ECE 701 Master's Thesis. These options are highly recommended if you like research and plan to pursue for your Ph.D. degree.

M.S. in Power and Energy Systems

Code	Title	Credits
Bridge Courses		
ECE 321	Random Signals and Noise	3
ECE 232	Circuits and Systems II	3
ECE 333	Signals and Systems	3
ECE 341	Energy Conversion	3
ECE 361	Electromagnetic Fields I	3
ECE 372	Electronic Circuits II	3
Total Credits		18

Code	Title	Credits
Core Courses		
ECE 601	Linear Systems	3

ECE 610	Power System Steady-State Analysis	3
Specialized Courses/Electives		
Select three of the following:		9
ECE 611	Transients in Power Systems	
ECE 616	Power Electronics	
ECE 618	Renewable Energy Systems	
ECE 698	Selected Topics in Electrical and Computer Engineering	
MGMT 620	Management of Technology	
Electives		**15**
ECE 613	Protection of Power Systems	
ECE 617	Economic Control of Interconnected Power Systems	
ECE 698	Selected Topics in Electrical and Computer Engineering	
ECE 698	Selected Topics in Electrical and Computer Engineering	
ECE 605	Discrete Event Dynamic Systems	
ECE 637	Internet and Higher-Layer Protocols	
ECE 661	Control System Components	
ECE 664	Real-time Computer Control Systems	
ECE 673	Random Signal Analysis I	
ME 607	Advanced Thermodynamics	
ME 610	Applied Heat Transfer	
ENE 671	Environmental Impact Analysis [1]	
IE 614	Safety Engineering Methods	
ARCH 665	Sustainable Design of Energy Efficient Buildings	
Total Credits		30

1. MGMT 692 Strategic Management and other business and management courses can be included as optional electives based on the student background, instructor approval and advisor approval.

M.S. in Telecommunications

Degree Requirements

The curriculum requires a basic knowledge of computer and communications fundamentals such as programming, data structures, computer architecture, signals and systems, and basic communication systems. Bridge courses do not count toward the degree. The bridge courses are selected from the following list depending on individual background in consultation with the graduate advisor. See the undergraduate catalog (http://catalog.njit.edu/archive/2019-2020/undergraduate/newark-college-engineering/#coursestext) for descriptions of 200- to 400-level courses.

Candidates must complete a minimum of 30 credits: 12 in core courses and 18 in elective courses in an area of specialization with a minimum overall GPA of 3.0. In addition, a minimum average 3.0 GPA is required in the five core courses. Students with an exceptionally strong telecommunications background may be allowed to replace required courses with advanced electives. Permission of the graduate advisor is required.

M.S. in Telecommunications (courses only)

Code	Title	Credits
Bridge Courses		
ECE 353	Computer Organization and Architecture	3
ECE 252	Microprocessors	3
CS 332	Principles of Operating Systems	3
CS 333	Introduction to UNIX Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
ECE 321	Random Signals and Noise	3
ECE 333	Signals and Systems	3
ECE 481	Digital Communications Systems	3

Code	Title	Credits
Core Courses		
ECE 642	Communication Systems I	3
ECE 644	Wireless Communication	3
CS 652	Computer Networks-Architectures, Protocols and Standards	3
or ECE 683	Computer Network Design and Analysis	
ECE 673	Random Signal Analysis I	3
Electives		
Select five of the following: [1]		15
CS 631	Data Management System Design	
CS 633	Distributed Systems	
CS 650	Computer Architecture	
or ECE 690	Computer Systems Architecture	
CS 656	Internet and Higher-Layer Protocols	
or ECE 637	Internet and Higher-Layer Protocols	
CS 665	Algorithmic Graph Theory	
CS 668	Parallel Algorithms	
CS 696	Network Management and Security	
or ECE 638	Network Management and Security	
ECE 673	Random Signal Analysis I	
ECE 742	Communication Systems II	
ECE 755	Advanced Topics in Digital Communications	
ECE 783	Computer Communication Networks	
Total Credits		27

1 These courses are to be used in an area of specialization.

M.S. in Telecommunciations (Master's project)

Code	Title	Credits
Bridge Courses		
ECE 353	Computer Organization and Architecture	3
ECE 252	Microprocessors	3
CS 332	Principles of Operating Systems	3
CS 333	Introduction to UNIX Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
ECE 321	Random Signals and Noise	3
ECE 333	Signals and Systems	3
ECE 481	Digital Communications Systems	3

1 ECE 321 Random Signals and Noise and ECE 333 Signals and Systems may be substituted for .

Code	Title	Credits
Core Courses		
ECE 642	Communication Systems I	3
ECE 644	Wireless Communication	3
CS 652	Computer Networks-Architectures, Protocols and Standards	3
or ECE 683	Computer Network Design and Analysis	
ECE 673	Random Signal Analysis I	3
Project		
ECE 700B	Master's Project	3
or CS 700B	Master's Project	
Electives		
Select five of the following: [1]		15

CS 631	Data Management System Design	
CS 633	Distributed Systems	
CS 650	Computer Architecture	
or ECE 690	Computer Systems Architecture	
CS 656	Internet and Higher-Layer Protocols	
or ECE 637	Internet and Higher-Layer Protocols	
CS 668	Parallel Algorithms	
CS 696	Network Management and Security	
or ECE 638	Network Management and Security	
ECE 673	Random Signal Analysis I	
ECE 742	Communication Systems II	
ECE 755	Advanced Topics in Digital Communications	
ECE 783	Computer Communication Networks	
Total Credits		30

[1] These courses are to be used in an area of specialization.

M.S. in Telecommunications (Master's thesis)

Code	Title	Credits
Bridge Courses		
ECE 353	Computer Organization and Architecture	3
ECE 252	Microprocessors	3
CS 332	Principles of Operating Systems	3
CS 333	Introduction to UNIX Operating Systems	3
CS 505	Programming, Data Structures, and Algorithms	3
ECE 321	Random Signals and Noise	3
ECE 333	Signals and Systems	3
ECE 481	Digital Communications Systems	3

Code	Title	Credits
Core Courses		
ECE 642	Communication Systems I	3
ECE 644	Wireless Communication	3
CS 652	Computer Networks-Architectures, Protocols and Standards	3
or ECE 683	Computer Network Design and Analysis	
ECE 673	Random Signal Analysis I	3
Thesis		
ECE 701C	Master's Thesis	6
or CS 701B	Master's Thesis	
Electives		
Select four of the following: [1]		12
CS 631	Data Management System Design	
CS 633	Distributed Systems	
CS 650	Computer Architecture	
or ECE 690	Computer Systems Architecture	
CS 656	Internet and Higher-Layer Protocols	
or ECE 637	Internet and Higher-Layer Protocols	
CS 668	Parallel Algorithms	
CS 696	Network Management and Security	
or ECE 638	Network Management and Security	
ECE 673	Random Signal Analysis I	
ECE 742	Communication Systems II	
ECE 755	Advanced Topics in Digital Communications	

ECE 783	Computer Communication Networks	
Total Credits		30

[1] These courses are to be used in an area of specialization.

Area of Specialization

The following are suggested areas of specialization and sample elective courses for each. Students may develop an individual area of specialization in consultation with a graduate advisor.

Management and Administration

Code	Title	Credits
CS 696	Network Management and Security	3
or ECE 638	Network Management and Security	

Communication Systems

Code	Title	Credits
ECE 673	Random Signal Analysis I	3
ECE 742	Communication Systems II	3
ECE 755	Advanced Topics in Digital Communications	3

Networking

Code	Title	Credits
CS 633	Distributed Systems	3
CS 650	Computer Architecture	3
or ECE 690	Computer Systems Architecture	
CS 656	Internet and Higher-Layer Protocols	3
or ECE 637	Internet and Higher-Layer Protocols	
CS 668	Parallel Algorithms	3
CS 696	Network Management and Security	3
or ECE 638	Network Management and Security	
ECE 639	Principles of Broadband Networks	3
ECE 673	Random Signal Analysis I	3
ECE 783	Computer Communication Networks	3

Information Technologies

Code	Title	Credits
CS 631	Data Management System Design	3
CS 696	Network Management and Security	3
or ECE 638	Network Management and Security	

Other CS and ECE courses related to telecommunications may be selected as elective courses with the written approval of the corresponding graduate advisor.

Ph.D. in Computer Engineering

Degree Requirements

To graduate, students must have an approved dissertation and are expected to attain an overall GPA of at least 3.5. Students need always to get departmental approval for the courses they take for their degree requirements.

Ph.D. in Computer Engineering (students with a master's in computer engineering or equivalent)

Code	Title	Credits
Electives		
700-level course work [1]		12
Dissertation		

ECE 790	Doctrl Dissrtn & Research [2]	0
Seminar		
ECE 791	Graduate Seminar [3]	0
Total Credits		12

1. No more than 6 credits may be ECE 725 or ECE 726 Independent Study. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. Additionally, ECE 630, ECE 632, ECE 639, ECE 681, ECE 657, ECE 618, ECE 692, ECE 690, ECE 605 and ECE 666 can be 700-level course substitutes because of lack of 700- level course in these tracks. Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.
2. Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (ECE 792B Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal. Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (ECE 790 (https://catalog.njit.edu/search/?P=CHE%20790)A Doct Dissertation & Res) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.
3. Students must register six semesters for this seminar. Student must attend at least 5 seminars per semester. Part-time students may request that this requirement be waived for some semesters.

Ph.D. in Computer Engineering (students with a Baccalaureate degree in computer engineering or equivalent)

Code	Title	Credits
Elective		
600 and 700-level courses [1]		36
Dissertation		
ECE 790	Doctrl Dissrtn & Research [2]	0
Seminar		
ECE 791	Graduate Seminar [3]	0
Total Credits		36

1. Ph.D. students with a recognized Baccalaureate degree are required to take eight 600-level or 700-level 3-credit courses (24 credits) of coursework beyond the Baccalaureate degree as well as four additional 700-level 3-credit courses (12 credits), for a total of twelve 3-credit courses (36 credits). Master's project (course 700), Master's thesis (course 701), or more than two independent study courses (courses 725 and 726) cannot be used to satisfy these coursework requirements. No more than 6 credits may be ECE 725 or ECE 726 Independent Study. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. Additionally, ECE 630, ECE 632, ECE 639, ECE 681, ECE 657, ECE 618, ECE 692, ECE 690, ECE 605 and ECE 666 can be replaced as 700-level courses because of lack of 700- level course in these tracks. Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.
2. Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (ECE 792B Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal. Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (ECE 790A Doct Dissertation & Res) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.
3. Students must register six semesters for this seminar. Student must attend at least 5 seminars per semester. Part-time students may request that this requirement be waived for some semesters.

Deadlines

Students who do not meet the following deadlines will be dismissed from the Ph.D. program.

- The required coursework for the Ph.D. program and the (major part of the) QE must be completed successfully by the end of the second year in the program.
- The dissertation proposal must be defended successfully either by the end of the third year in the Ph.D. program or four semesters after registering for the first time in the 792 pre-doctoral research course, whichever occurs earlier.
- The dissertation must be defended successfully by the end of the sixth year in the Ph.D. program.

Selection of Dissertation Advisor

Students must select a dissertation topic and advisor within 6 months of joining the program. Advisors are assigned based on student preferences and availability of funding. Change of advisor requires consent of the previous advisor and departmental approval. In cases where more than one advisor is directing the dissertation, the primary advisor must be on the core departmental faculty.

Qualifying Examination

Goal: ECE Department's qualifying exam needs to be a constructive component in the development of a student's research skills and along with the course work requirements to identify students qualified for research.

Exam Structure: The Ph. D. Qualifying Exam has two parts: I) GPA requirement on selected courses, and II) Research potential assessment.

Part I. GPA Course Requirements:

ECE Course Requirement: Prequalified doctoral students are required to pass four courses selected from a list of relevant doctoral courses ("core courses") with a GPA of at least 3.5 or higher.

Each research group (Communications, Signal Processing and Microwave; Computer Networking; Computer Architecture, Electronic and Photonic Devices; and Intelligent Systems) has its own list of courses. Courses are listed at the bottom of this section.

Part II. Research Potential Assessment Oral Qualifier:

The research potential assessment oral qualifying examination must be taken within the first year from the time the student starts the Ph.D. program if he/she has a MS degree. In the case of a student accepted into the BS-Ph.D. track, the exam must be taken within two years from the time the student starts the Ph.D. program. For the students accepted with a MS degree, within the first two semesters from the time the student starts the Ph.D. program the student must complete one Independent Research course in his/her research area of interest. For the Independent Research course, the student registers with a faculty member who may or may not be the student's prospective Ph.D. advisor.

The oral exam committee will be assigned by the Associate Chair for Graduate Studies of the ECE Department. It will be chaired by a faculty member from an area different from the student's area of interest. In addition to the Chair, the committee will include three faculty members in the student's area of interest. The supervisor of the independent research work or the student's prospective advisor may be part of the committee.

A student must send in an official application for taking the oral Qualifying exam to the Associate Chair for Graduate Studies, at least one month before the target date of the oral exam committee. The student is responsible to find a time such that all committee members can attend. In the application, the student should identify the research focus area for the exam and outline how the course requirements (if any) for that focus area have been met.

For the oral exam, the student will prepare a written report to the committee and to the associate chair for graduate studies at least one week before the exam date. The report should be written following the standard format of a conference paper, with 4-6 pages in double column, font size 11. The subject of the oral exam is to be chosen by the student. It is recommended that this choice be made in consultation with a faculty advisor and the ECE associate chair for graduate studies. A suitable basis for the examination may include, but is not restricted to:

• A paper/report (conference, journal, technical report, patent, and/or published or submitted)

• A conference paper submission based on research under the supervision of a faculty advisor.

• An M.S. thesis in preparation or previously completed thesis

• A final project report derived from an ECE Independent Study course.

During the exam the student will make a 30-minute oral presentation of his/her own independent research to the oral exam committee.

The oral presentation will be followed by an open-ended question and answer session that may include questions specific to the research project as well as questions generally relevant to the research area regarding fundamental knowledge underpinning the project topic. In addition, basic questions from various different areas can be asked to determine student's breadth of understanding.

Since this examination will occur in the early stages of research, and since the oral exam is not a doctoral defense, the presented paper need not lead to a Ph.D. thesis proposal. For the examination committee, evaluation of the originality and novelty of the research contribution will be secondary to an evaluation of the student's critical thinking skills. Specifically, the committee will focus on the student's ability to analyze, interpret and articulate both strengths and weaknesses of the work. Outstanding students, who have published several papers prior to starting their Ph.D. program, are encouraged to take the oral qualifying exam during the first semester of the Ph.D. program.

The committee will provide a written evaluation of the student's potential for Ph.D. research (in terms of technical ability, and oral and written communications skill) to the department. The committee members can seek input from the prospective Ph.D. advisor when making such evaluation, but the advisor is excluded from participating in formulating the written evaluation. Each member of the Ph. D. Qualifying committee votes to pass or fail the student. The written report should include the vote. The vote of 3:1 or 4:0 is needed for the student to pass the Ph.D. Qualifying Exam.

The ECE department will make the final decision of pass or fail based on the exam committee's report. The student will be allowed two chances to take the Ph.D. Qualifying Exam. The second attempt must be taken within six months from the time the student made the first qualifying exam. Failure to do so will automatically dismiss the student's qualification for further doctoral study.

The Ph. D. Qualifying Exam is offered year around. Five Areas of the Ph. D. Qualifying Exam

• Communications, Signal Processing and Microwave

• Computer Networking

• Computer Architecture

• Electronic and Photonic Devices

• Intelligent Systems

The student needs to select a minimum of 4 courses out of 6 courses (or equivalent) required by each area: Students can take additional courses as per the advisement of area. Here are the suggested courses for different areas:

Communication	Signal Processing	Microwave	Networking	Computer Architecture	Electronic & Photonic	Intelligent Systems
ECE 725	ECE 725	ECE 725	ECE 725	ECE 725	ECE 725	ECE 725
ECE 726	ECE 726	ECE 726	ECE 726	ECE 726	ECE 726	ECE 726
ECE 742	ECE 740	ECE 742	ECE 783	ECE 690	ECE 758	ECE 788
ECE 744	ECE 743	ECE 630	ECE 681	ECE 758	ECE 657	ECE 666
ECE 776	ECE 788	ECE 632	ECE 744	ECE 692	ECE 756	ECE 605
ECE 777	ECE 777	ECE 744	ECE 639	ECE 689	ECE 618	ECE 618

Formation of Dissertation Committee

A dissertation committee must be formed within three months after passing the qualifying examination. The dissertation committee must be approved by the ECE Department Graduate Affairs Committee at the time of its formation and before the presentation of the research proposal. The dissertation committee chairperson typically is the doctoral candidate's program advisor, but other faculty may be selected, provided that they are from the ECE Department. The committee consists of a minimum of five members, one of whom is external to the ECE Department or to NJIT, and at least three of whom are members of the ECE department. The dissertation advisor must be a tenure-track or tenured faculty member at NJIT. If the dissertation advisor is an ECE department faculty member, then the chair of the student's dissertation committee may be any tenure-track or tenured faculty member in the ECE Department at NJIT. If the dissertation advisor is not a member of the ECE department at NJIT, then the chair of the student's dissertation committee must be a tenured faculty member in the ECE department at NJIT. If the dissertation advisor is not an ECE department faculty member, there must be a co-advisor who is a tenure-track or tenured faculty member in the ECE department at NJIT.

Research Proposal

Doctoral candidates must prepare a written research proposal for approval by their dissertation committee. The proposal must be presented after formation of the committee but within twelve months after passing the qualifying exam. The proposal should show that facilities are available to do the work. Research is expected to investigate or develop a unique contribution to science and technology. Research may be experimental, analytical, applied, or theoretical, provided it satisfies these criteria and is approved by the dissertation committee. The research proposal would normally include title and goal of the proposed dissertation; a detailed discussion of background material, including a literature search; a summary of work accomplished to date; a statement of how the residency requirement will be met; and a proposed time table for completion of research.

Dissertation and Defense

A dissertation should demonstrate original research that contributes to knowledge in the field. The dissertation should result in scholarly publication and must be defended in a publicly-announced oral defense. A typed version of the completed dissertation should be available to the committee at least three (3) weeks before the oral defense is scheduled and an unbound copy of the thesis should be available in the Department Secretary's office (235 ECEC) three weeks before the defense. Successful defense of the dissertation is determined by vote of the dissertation committee. All members of the committee must be present to hear the defense. In regard to format, the standard reference is the latest edition of the Estrin/Roche manual Guidelines for Scientific and Professional Theses. The Office of Graduate Studies policies on number of copies, deadlines, and submission of dissertation and abstracts are also to be followed. Every member of the dissertation committee must sign the approval page of the final dissertation document. Students cannot be certified by the ECE department for the doctoral degree until the student publishes at least one paper in a peer-reviewed journal deemed of acceptable quality by the dissertation advisor.

Ph.D. in Electrical Engineering

Degree Requirements

To graduate, students must have an approved dissertation and are expected to attain an overall GPA of at least 3.5. Students need always to get departmental approval for the courses they take for their degree requirements.

Ph.D. in Electrical Engineering (students with a master's in electrical engineering or equivalent)

Code	Title	Credits
Electives		
700-level courses [1]		12
Dissertation		
ECE 790	Doctrl Dissrtn & Research [2]	0
Seminar		
ECE 791	Graduate Seminar [3]	0
Total Credits		12

1 No more than 6 credits may be ECE 725 Independent Study I or ECE 726 Independent Study II Independent Study. 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. Additionally, ECE 630, ECE 632, ECE 639, ECE 681, ECE 657, ECE 618, ECE 692, ECE 690, ECE 605 and ECE 666 can be 700-level course substitutes because of lack of 700- level course in these tracks. Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.

2 Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research(ECE 792B Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal. Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (ECE 790A Doctrl Dissrtn & Research) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.

3 Students must register six semesters for this seminar. Student must attend at least 5 seminars per semester. Part-time students may request that this requirement be waived for some semesters.

Ph.D. in Electrical Engineering (students with a Baccalaureate degree in electrical engineering or equivalent)

Code	Title	Credits
Electives		
600-700-level courses [1]		36
Dissertation		
ECE 790	Doctrl Dissrtn & Research [2]	0
Seminar		
ECE 791	Graduate Seminar [3]	0
Total Credits		36

1 Ph.D. students with a recognized Baccalaureate degree are required to take eight 600-level or 700-level 3-credit courses (24 credits) of coursework beyond the Baccalaureate degree as well as four additional 700-level 3-credit courses (12 credits), for a total of twelve 3-credit courses (36 credits). Master’s project (course 700), Master’s thesis (course 701), or more than two independent study courses (courses 725 and 726) cannot be used to satisfy these coursework requirements. No more than 6 credits may be ECE 725 Independent Study I or ECE 726 Independent Study II . 700-level courses may be substituted by 600-level courses if the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. Additionally, ECE 630, ECE 632, ECE 639, ECE 681, ECE 657, ECE 618, ECE 692, ECE 690, ECE 605 and ECE 666 can be replaced as 700-level courses because of lack of 700- level course in these tracks. Whether or not a program requires additional courses above the aforementioned minimum requirements, a Ph.D. student's dissertation committee may ask the student to take additional courses.

2 Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (ECE 792B Pre-Doctoral Research) per semester until they defend successfully the dissertation proposal. Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (ECE 790A Doctrl Dissrtn & Research) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.

3 Students must register six semesters for this seminar. Student must attend at least 5 seminars per semester. Part-time students may request that this requirement be waived for some semesters.

Deadlines

Students who do not meet the following deadlines will be dismissed from the Ph.D. program.

- The required coursework for the Ph.D. program and the (major part of the) QE must be completed successfully by the end of the second year in the program.
- The dissertation proposal must be defended successfully either by the end of the third year in the Ph.D. program or four semesters after registering for the first time in the 792 pre-doctoral research course, whichever occurs earlier.
- The dissertation must be defended successfully by the end of the sixth year in the Ph.D. program.

Selection of Dissertation Advisor

Students must select a dissertation topic and advisor within 6 months of joining the program. Advisors are assigned based on student preferences and availability of funding. Change of advisor requires consent of the previous advisor and departmental approval. In cases where more than one advisor is directing the dissertation, the primary advisor must be on the core departmental faculty.

Qualifying Examination

Goal: ECE Department's qualifying exam needs to be a constructive component in the development of a student's research skills and along with the course work requirements to identify students qualified for research.

Exam Structure: The Ph. D. Qualifying Exam has two parts: I) GPA requirement on selected courses, and II) Research potential assessment.

Part I. GPA Course Requirements:

ECE Course Requirement: Prequalified doctoral students are required to pass four courses selected from a list of relevant doctoral courses ("core courses") with a GPA of at least 3.5 or higher.

Each research group (Communications, Signal Processing and Microwave; Computer Networking; Computer Architecture, Electronic and Photonic Devices; and Intelligent Systems) has its own list of courses. Courses are listed at the bottom of this section.

Part II. Research Potential Assessment Oral Qualifier:

The research potential assessment oral qualifying examination must be taken within the first year from the time the student starts the Ph.D. program if he/she has a MS degree. In the case of a student accepted into the BS-Ph.D. track, the exam must be taken within two years from the time the student starts the Ph.D. program. For the students accepted with a MS degree, within the first two semesters from the time the student starts the Ph.D. program the student must complete one Independent Research course in his/her research area of interest. For the Independent Research course, the student registers with a faculty member who may or may not be the student's prospective Ph.D. advisor.

The oral exam committee will be assigned by the Associate Chair for Graduate Studies of the ECE Department. It will be chaired by a faculty member from an area different from the student's area of interest. In addition to the Chair, the committee will include three faculty members in the student's area of interest. The supervisor of the independent research work or the student's prospective advisor may be part of the committee.

A student must send in an official application for taking the oral Qualifying exam to the Associate Chair for Graduate Studies, at least one month before the target date of the oral exam committee. The student is responsible to find a time such that all committee members can attend. In the application, the student should identify the research focus area for the exam and outline how the course requirements (if any) for that focus area have been met.

For the oral exam, the student will prepare a written report to the committee and to the associate chair for graduate studies at least one week before the exam date. The report should be written following the standard format of a conference paper, with 4-6 pages in double column, font size 11. The subject of the oral exam is to be chosen by the student. It is recommended that this choice be made in consultation with a faculty advisor and the ECE associate chair for graduate studies. A suitable basis for the examination may include, but is not restricted to:

• A paper/report (conference, journal, technical report, patent, and/or published or submitted) • A conference paper submission based on research under the supervision of a faculty advisor.

• An M.S. thesis in preparation or previously completed thesis

• A final project report derived from an ECE Independent Study course.

During the exam the student will make a 30-minute oral presentation of his/her own independent research to the oral exam committee.

The oral presentation will be followed by an open-ended question and answer session that may include questions specific to the research project as well as questions generally relevant to the research area regarding fundamental knowledge underpinning the project topic. In addition, basic questions from various different areas can be asked to determine student's breadth of understanding.

Since this examination will occur in the early stages of research, and since the oral exam is not a doctoral defense, the presented paper need not lead to a Ph.D. thesis proposal. For the examination committee, evaluation of the originality and novelty of the research contribution will be secondary to an evaluation of the student's critical thinking skills. Specifically, the committee will focus on the student's ability to analyze, interpret and articulate both strengths and weaknesses of the work. Outstanding students, who have published several papers prior to starting their Ph.D. program, are encouraged to take the oral qualifying exam during the first semester of the Ph.D. program.

The committee will provide a written evaluation of the student's potential for Ph.D. research (in terms of technical ability, and oral and written communications skill) to the department. The committee members can seek input from the prospective Ph.D. advisor when making such evaluation, but the advisor is excluded from participating in formulating the written evaluation. Each member of the Ph. D. Qualifying committee votes to pass or fail the student. The written report should include the vote. The vote of 3:1 or 4:0 is needed for the student to pass the Ph.D. Qualifying Exam.

The ECE department will make the final decision of pass or fail based on the exam committee's report. The student will be allowed two chances to take the Ph.D. Qualifying Exam. The second attempt must be taken within six months from the time the student made the first qualifying exam. Failure to do so will automatically dismiss the student's qualification for further doctoral study.

The Ph. D. Qualifying Exam is offered year around. Five Areas of the Ph. D. Qualifying Exam

• Communications, Signal Processing and Microwave

• Computer Networking

• Computer Architecture

• Electronic and Photonic Devices

• Intelligent Systems

The student needs to select a minimum of 4 courses out of 6 courses (or equivalent) required by each area: Students can take additional courses as per the advisement of area. Here are the suggested courses for different areas:

Communication	Signal Processing	Microwave	Networking	Computer Architecture	Electronic & Photonic	Intelligent Systems
ECE 725	ECE 725	ECE 725	ECE 725	ECE 725	ECE 725	ECE 725
ECE 726	ECE 726	ECE 726	ECE 726	ECE 726	ECE 726	ECE 726
ECE 742	ECE 740	ECE 742	ECE 783	ECE 690	ECE 758	ECE 788
ECE 744	ECE 743	ECE 630	ECE 681	ECE 758	ECE 657	ECE 666
ECE 776	ECE 788	ECE 632	ECE 744	ECE 692	ECE 756	ECE 605
ECE 777	ECE 777	ECE 744	ECE 639	ECE 689	ECE 618	ECE 618

Formation of Dissertation Committee
A dissertation committee must be formed within three months after passing the qualifying examination. The dissertation committee must be approved by the ECE Department Graduate Affairs Committee at the time of its formation and before the presentation of the research proposal. The dissertation committee chairperson typically is the doctoral candidate's program advisor, but other faculty may be selected, provided that they are from the ECE Department. The committee consists of a minimum of five members, one of whom is external to the ECE Department or to NJIT, and at least three of whom are members of the ECE department. The dissertation advisor must be a tenure-track or tenured faculty member at NJIT. If the dissertation advisor is an ECE department faculty member, then the chair of the student's dissertation committee may be any tenure-track or tenured faculty member in the ECE Department at NJIT. If the dissertation advisor is not a member of the ECE department at NJIT, then the chair of the student's dissertation committee must be a tenured faculty member in the ECE department at NJIT. If the dissertation advisor is not an ECE department faculty member, there must be a co-advisor who is a tenure-track or tenured faculty member in the ECE department at NJIT.

Research Proposal
Doctoral candidates must prepare a written research proposal for approval by their dissertation committee. The proposal must be presented after formation of the committee but within twelve months after passing the qualifying exam. The proposal should show that facilities are available to do the work. Research is expected to investigate or develop a unique contribution to science and technology. Research may be experimental, analytical, applied, or theoretical, provided it satisfies these criteria and is approved by the dissertation committee. The research proposal would normally include title and goal of the proposed dissertation; a detailed discussion of background material, including a literature search; a summary of work accomplished to date; a statement of how the residency requirement will be met; and a proposed time table for completion of research.

Dissertation and Defense
A dissertation should demonstrate original research that contributes to knowledge in the field. The dissertation should result in scholarly publication and must be defended in a publicly-announced oral defense. A typed version of the completed dissertation should be available to the committee at least three (3) weeks before the oral defense is scheduled and an unbound copy of the thesis should be available in the Department Secretary's office (235 ECEC) three weeks before the defense. Successful defense of the dissertation is determined by vote of the dissertation committee. All members of the committee must be present to hear the defense. In regard to format, the standard reference is the latest edition of the Estrin/Roche manual Guidelines

for Scientific and Professional Theses. The Office of Graduate Studies policies on number of copies, deadlines, and submission of dissertation and abstracts are also to be followed. Every member of the dissertation committee must sign the approval page of the final dissertation document. Students cannot be certified by the ECE department for the doctoral degree until the student publishes at least one paper in a peer-reviewed journal deemed of acceptable quality by the dissertation advisor.

Power Systems Engineering

The objective of the certificate in Power Systems Engineering is to provide students with the knowledge to be involved with the technology advancements and future developments in power generation, controls, and management as well as with alternate and new energy resources. This program will prepare engineers to work in the power and energy industry. Academic programs in energy technology and management are needed to prepare the future workforce for the energy and power industry as more than fifty percent of the workforce in the power industry is retiring during this decade. At the same time, developing new, clean, and more efficient energy resources and technologies is of global significance.

Who is suited for this program?

Power Systems Engineering is ideal for preparing future engineers in the power and energy industry. Additionally, it fits students who are interested in technology advancements and future developments in the power generation, control, and management as well as alternate and new resources.

What are the Required Courses?

Code	Title	Credits
Core Courses		
ECE 610	Power System Steady-State Analysis	3
ECE 618	Renewable Energy Systems	3
Electives		
Select two of the following:		6
ECE 611	Transients in Power Systems	
ECE 613	Protection of Power Systems	
ECE 618	Renewable Energy Systems	
ECE 698	Selected Topics in Electrical and Computer Engineering	

What will I learn?

- Power system steady-state analysis of power system networks, particularly real and reactive power flows under normal conditions and current flows under faulty conditions. Symmetrical components and digital solutions are emphasized.
- Computer methods applied to power systems and digital computer techniques proven successful in the solution of power system problems, particularly in the electric utility industry. Emphasis on short-circuit, load flow, and transient stability problems. Matrix sparsity is considered.
- Transient performance of power systems with lumped properties, interruption of arcs, restriking voltage, re-ignition inertia effects, switching of rotational systems, magnetic saturation in stationary networks, harmonic oscillations, saturated systems, transient performance of synchronous machines.
- Protection of power systems
- Theoretical developments and computer methods in determining economic operation within the boundaries of a given steam-electric operating area. Energy accounting control and economic theories for interconnected steam and hydroelectric power systems.

Why study Power Systems Engineering at NJIT?

Energy resources and technology has become a key thrust area of significant importance at several leading institutions. With the synergy in nanotechnology, solar cells and other related sciences at NJIT, an advanced energy technology initiative was formulated to offer an academic and research program in energy resources, technology management, and alternate energy research.

Academic programs in energy technology and management are much needed to prepare the future workforce for the energy and power industry as more than 50% of the workforce in the power industry is retiring in this decade. At the same time, developing new, clean and more efficient energy resources and technologies is of global significance.

Prerequisites

Applicants are expected to have undergraduate backgrounds in physics, mathematics (through differential equations and vector analysis), electrical networks and devices, electronics, analysis and design methods, transients, electromagnetic fields, and appropriate laboratory work in some of these areas. Completion of a Bachelor’s degree with a overall cumulative Grade Point Average of 2.8 or higher on a 4.0 scale.

Related Degree Programs

All credits for the Power Systems Engineering Certificate relates in its entirety to either MS in Electrical Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/electrical-ms/) or MS in Power and Energy Systems (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/electrical-computer/power-energy-systems-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/power-systems-engineering-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Mengchou Zhou (http://ece.njit.edu/people/zhou.php)

Mechanical and Industrial Engineering

Mechanical Engineering

Mechanical engineering is concerned with the design, development, manufacture, and operation of a wide variety of energy conversion and machine systems. The research and education facilities of the department are housed in the 60,000-square-foot Mechanical Engineering Building. Major research laboratories include Particle Technology, Energetic Materials, Machine Vision and Motion Analysis, Waterjet Machining, Robotics and Intelligent Manufacturing, Bearing Lubrication, and Plastic Processing and Analysis.

Master of Science in Mechanical Engineering

A program for engineering graduates who want advanced professional preparation and further graduate study in mechanical engineering.

Admission Requirements

Applicants are expected to have an undergraduate degree in mechanical engineering or a related field. General admissions requirements for master's programs as described in this catalog apply to applicants to the M.S. in Mechanical Engineering. Sufficient preparation in science and mathematics to complete the course of study is also necessary.

Doctor of Philosophy in Mechanical Engineering

This is a program for superior students with master's degrees in mechanical engineering or allied fields who wish to do advanced research in an area of mechanical engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in mechanical engineering may be accepted directly into the doctoral program.

Admission Requirements

Applicants should have a master's degree from an accredited institution, and have successfully taken courses in applied mathematics and engineering sciences. In addition, applicants must fulfill the admissions requirements for doctoral study as specified in the Admissions section of this catalog. Students who lack an appropriate background will be required to take additional courses before gaining admission to the program. These courses are prescribed by the department on an individual basis and may not be applied as degree credit.

Industrial Engineering

Industrial Engineering (IE) is a field of study intended for professionals who are interested in managing and analyzing complex systems. IEs typically formulate mathematical and/or digital simulation models of these systems with the intention of improving system and economic performance. Unique and in contrast to other traditional disciplines in engineering IEs focus on information driven human decision making and a broad based systems perspective. IEs consider themselves to be virtually any setting where outcomes are influenced by key decisions.

Master of Science in Industrial Engineering

Individuals with a diversity of technical background have completed the MSIE degree. These individuals are attracted by the historically strong role played by IEs in modeling and analysis within traditional production and distribution settings, that now extend to healthcare, transportation, and a wide range of service industries. Program provides advanced training in operations research, supply chain, and process modeling and analysis. All courses are offered primarily in evening and weekend sessions at our Newark campus, and ideal for working professionals. Many courses are also offered online in an E-learning mode.

A program for individuals who seek professional advancement in the industrial engineering field.

Admission Requirements

A B.S. degree in an engineering, information technology, information technology, operations management, science, or related technical discipline. A bridge program is also available for suitable candidates.

Graduate Certificate Program

A 12-credit graduate certificate in Operations Productivity is available as a step toward this degree. Please see **Graduate Certificates** in this catalog for further information. For more information about continuing and distance education, please contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; email: cpe@njit.edu.

Doctor of Philosophy in Industrial Engineering

The objectives of the Ph.D. in Industrial Engineering program are to provide the knowledge and develop the skills that students need to become leaders of research in academia, industry and government.

This program is intended for highly qualified students who wish to pursue advanced research in industrial engineering and related areas. The program emphasizes two areas: manufacturing systems and assurance sciences, and human factors and occupational safety.

Admission Requirements

Applicants should have a master's degree in industrial engineering or a related field. In certain circumstances, a qualified student with a bachelor's degree in industrial engineering or related field may be admitted into the program.

Engineering Management

By drawing on the diverse resources available through the university and surrounding industry, the M.S. in Engineering Management program develops engineers and other technically trained individuals for leadership roles in a technologically-based, project-oriented enterprise.

Focus on interdisciplinary course work and research provides students with an advanced background in both the theoretical and practical aspects of managing technical/engineering projects and programs via case studies, role playing, and course work. The engineering management program faculty bring to the classroom a critical blend of practical and academic experience.

Master of Science in Engineering Management

The program is particularly valuable to individuals who have a number of years of experience in industry, government, and service organizations, or those who have been entrepreneurs. It provides these professionals with broad-based knowledge and skills to succeed as organizational managers and project managers, from conceptualization through implementation.

Admission Requirements

Eligibility for admission requires completion of an undergraduate degree in engineering, the sciences or a closely related area. Students are expected to have achieved an undergraduate GPA of at least 2.8 on a 4.0 scale. Students not satisfying the above requirement will be considered for conditional admission on a case-by-case basis. In some cases, a bridge program will be required to qualify for matriculation.

Graduate Certificate Program

A 12-credit graduate certificate in Construction Management, Operations Productivity, Pharmaceutical Management or Project Management is available as a step toward this degree. Please see **Graduate Certificates** in this catalog for further information. For more information about continuing and distance education, please contact the Division of Continuing Professional Education, 1-800-624-9850 or 973-596-3060; email: cpe@njit.edu.

Off-Campus Programs

At extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. NJIT faculty teach all courses. For locations, see **Extension Programs** in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described above) to qualified students who have access to the Internet and a VCR. In addition, distance-based, 12-credit graduate certificates in **Construction Management, Operations Productivity, Pharmaceutical Management or Project Management,** are available as a step toward this degree. See **Graduate Certificates** in this catalog. For further information about extension programs, ACCESS/NJIT programs, and graduate certificates, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; email cpe@njit.edu.

Healthcare Systems Management

The MS in Healthcare Systems Management will train and educate graduates in the application of systems analysis and quantitative methods in managing the various components of the healthcare delivery system. The program provides graduates with contemporary knowledge and the needed technical expertise for the efficient design, management and operation of healthcare facilities, including hospitals, nursing facilities, clinics, and pharmacies. This expertise will span the subjects of systems engineering, operations management, and advanced information technologies and will present concepts and tools for both reducing healthcare system costs and increasing the quality of healthcare services. Healthcare Systems are defined as the network of physical facilities, equipment, informational technologies, and patient flow processes that are associated with providing and delivering healthcare services. Graduates would find jobs in hospitals and healthcare organizations, serving in progressively more responsible positions in the quality improvement, decision support, information technology, patient accounting, facilities planning, or operations management departments.

Admission Requirements

A B.S. degree in a technical discipline (e.g., Engineering, Computer Science, Informational Technology, Physics etc.). A bridge program is also available for suitable candidates from other degree majors. Individuals who have been working in a healthcare related organization for two or more years, and are now looking for additional skills to further progress their careers in the healthcare industry would be ideal candidates.

Manufacturing Systems Engineering

The manufacturing engineering discipline addresses problems and methods of manufacturing systems integration. The M.S. in Manufacturing Systems Engineering program emphasizes the interrelationships between manufacturing equipment, processes and controls, and their integration into production factories.

The curriculum is computer and multimedia intensive and includes the use and understanding of new technologies such as robotics, programmable logic controllers, microprocessors and computer-integrated manufacturing and their application in automated production, assembly, automated inspection, and automated packaging. Focus is on computer-aided design and computer-aided manufacturing. Automation laboratories are used that contain many state-of-the-art devices including several industrial robots, CNC millers, CNC lathes, computer vision systems, and a fully automated flexible manufacturing system.

Master of Science in Manufacturing Systems Engineering

This is an interdisciplinary program of advanced study for individuals with backgrounds in engineering, focusing on efficient production in technology-intensive manufacturing industries.

Admission Requirements

Applicants should be graduates of an accredited undergraduate engineering program. Students with degrees in science may also be considered.

Occupational Safety and Health Engineering

The curriculum has been designed in accordance with the National Institute for Occupational Safety and Health (NIOSH), which sponsors the program. Through course work and research, individuals are exposed to all of the principal areas of concern to the entry-level safety professional, including how technology and hazardous materials affect the safety of the workplace.

NJIT's program is just one of a handful offered in the United States and the only master's-level program in New Jersey. NIOSH offers a limited number of stipends and tuition remission grants to qualified students.

Master of Science in Occupational Safety and Health Engineering

This program educates engineers in the specialty of occupational safety and health. Upon graduation, students are able to assume both the technical and managerial responsibilities of safety professionals.

Admission Requirements

An accredited bachelor's degree in an engineering or scientific field is normally required.

Pharmaceutical Systems Management

The MS program in Pharmaceutical Management (MSPhM) is designed to train and educate professionals for careers in the pharmaceutical industry by providing them with skills in the areas of quantitative systems analysis, planning and design of pharmaceutical process operations, and project management and implementation, relative to all technology intensive operations in this highly sophisticated industry. Application areas will include manufacturing operations, systems automation, packing and distribution, quality control and regulatory compliance, process and product validation, and supply chain management. Offered by the Department of Industrial and Management Systems Engineering in collaboration with the Pharmaceutical Engineering program, degree integrates a strong focus on technical oriented operations management with advanced knowledge of pharmaceutical manufacturing, validation, research and development processes.

Admission Requirements

A B.S. degree in an engineering, information technology, science, or related technical discipline. A bridge program is also available for suitable candidates from other majors. Individuals who have been working in the pharmaceutical industry for two or more years, and are now looking for additional skills to further progress their careers would be ideal candidates.

NJIT Faculty

A

Abdel-Malek, Layek, Professor

Abdou, George, Associate Professor

B

Bengu, Golgen, Associate Professor

Bladikas, Athanassios, Associate Professor

C

Cai, Wenbo, Assistant Professor

Caudill, Reggie J, Professor

Chen, Rong-Yaw, Professor Emeritus

Chester, Shawn A., Assistant Professor

D

Das, Sanchoy K., Professor

Droughton, John V., Professor Emeritus

F

Fenster, Saul K., Professor Emeritus

Fischer, Ian S., Professor

Florio, Pasquale J., Associate Professor

H

Harnoy, Avraham, Professor

Hatch, C., Richard, Professor Emeritus

J

Ji, Zhiming, Associate Professor

K

Kirchner, Robert P., Professor Emeritus

Koplik, Bernard, Professor

Kountouras, Harry V., Senior University Lecturer

L

Lee, Eon Soo, Assistant Professor

Linden, Martin J., Professor Emeritus

M

Mani, Balraj Subra, University Lecturer

McDermott, Kevin J., Associate Professor

N

Nadimpalli, Siva P.V., Assistant Professor

Narh, Kwabena A., Professor

R

Rao, I. Joga, Professor

Rosato, Anthony D., Professor

S

Samardzic, Veljko, University Lecturer

Singh, Pushpendra, Professor

Sodhi, Rajpal Singh, Professor

Surjanhata, Herli, Senior University Lecturer

T

Tricamo, Stephen J., Professor

W

Wilson, Charles E., Professor Emeritus

Wolf, Carl, Professor Emeritus

Z

Zhu, Chao, Professor

Programs

- Engineering Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/)
- Healthcare Systems Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/healthcare-systems-management-ms/)
- Industrial Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/industrial-ms/)
- Manufacturing Systems Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/manufacturing-systems-ms/)
- Mechanical Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/mechanical-ms/)
- Occupational Safety and Health Engineering - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/occupational-safety-health-ms/)
- Pharmaceutical Systems Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/pharmaceutical-systems-management-ms/)

Programs

- Industrial Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/industrial-phd/)
- Mechanical Engineering - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/mechanical-phd/)

Programs

- Project Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/project-management-cert/)
- Supply Chain Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/supply-chain-engineering-cert/)

Mechanical and Industrial Engineering Courses

IE 501. Fundamentals of Industrial Engineering. 3 credits, 3 contact hours.
Basic concepts of industrial engineering for students who lack an undergraduate degree in the discipline, including: manufacturing processes, work methods and measurement concepts, basics of human factors, quality control, facilities design, production planning, operations research tools, and simulation models.

IE 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Restriction: permission from the industrial engineering program director and the Division of Career Development Services. Cooperative education internship providing on-the-job reinforcement of academic programs in industrial engineering. Work assignments and projects are developed by the co-op office in consultation with the industrial engineering program director. Work assignments are related to student's major and are evaluated by faculty coordinators in the IE department. Course cannot be applied toward degree credit.

IE 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Restriction: permission from the industrial engineering program director and the Division of Career Development Services. Course cannot be applied toward degree credit.

IE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Restriction: graduate standing and permission from the industrial engineering program director, and the Division of Career Development Services. Course cannot be applied toward degree credit.

IE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

IE 601. Measurement Methods for Performance Analysis of Operations. 3 credits, 3 contact hours.
Prerequisite: undergraduate mathematics for management science, or EM 602. Quantitative study of various analytical methods for designing and evaluating systems employed in the management of complex enterprises such as decision-making, efficiency measurement, and methods for obtaining optimal system performance.

IE 603. Behavioral Science in Engineering Organization. 3 credits, 3 contact hours.
Prerequisite: undergraduate probability and statistics, or EM 503. A study of scientific research on human behavior in organizations. Processes and problems of communication in engineering activities; line-staff and supervisor-subordinate relationships; formal and informal organizations; organization models; and technical and social structure of organizations.

IE 604. Advanced Engineering Statistics. 3 credits, 3 contact hours.
Prerequisite: IE 331 (see undergraduate catalog for description) or equivalent. The foundations of modern quality improvement, scientific basis of quality engineering, probability, statistical inference, statistical experimental design issues such as randomized blocks, factorial design at different levels, application to factorial design, building models, and implementation and critique of Taguchi's contributions. Statistical software is used in the data analysis.

IE 605. Engineering Reliability. 3 credits, 3 contact hours.
Prerequisite: statistics. Concepts of modern reliability applied to practical industrial problems: statistical concepts, reliability through design, reliability through testing, analysis of reliability data, and the organization and management of a reliability program. Offered alternate years.

IE 606. Maintainability Engineering. 3 credits, 3 contact hours.
Prerequisite: statistics. Factors affecting maintainability design applied to military and industrial problems: statistical concepts; maintainability prediction, allocation, and demonstration; availability, system and costeffectiveness; provisioning; optimal maintenance policies; and management of a maintainability program.

IE 608. Product Liability Control. 3 credits, 3 contact hours.
Product liability and the effect of legal doctrines on minimizing hazards of design and manufacture. Use of actuarial techniques and legal precedents applicable to design, manufacturing, advertising, and marketing problems: warranties, notices, disclaimers, definition of liability, use of expert witnesses, reliability prediction and analysis methods, safety engineering concepts, and design review. A review of government regulations for safety and protection, as well as mandatory and voluntary standards will also be included.

IE 609. Advanced Analytical Engineering Statistics. 3 credits, 3 contact hours.
Prerequisite: IE 604. An extension of the techniques of engineering statistical analysis to industrial applications. Emphasis is placed on the design of experiments and analysis of tests for multivariate level problems.

IE 610. Transportation Economics. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in economics. Principles of engineering economy. Costs of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. Same as TRAN 610.

IE 614. Safety Engineering Methods. 3 credits, 3 contact hours.
Prerequisites: introductory course in statistics and industrial or construction management. Application of selected safety engineering methods to detect, correct, and prevent unsafe conditions and procedures in future practice. Methods selected are from safety management and programs; loss prevention; fire protection; systems safety; the design of buildings and other facilities; and the design of products, machinery, and equipment. Engineering problems in designing and constructing a hazard-free environment.

IE 615. Industrial Hygiene and Occupational Health. 3 credits, 3 contact hours.
Prerequisites: one year of college physics and one semester of college chemistry or biology. Introduction to industrial hygiene. Recognition, evaluation and control of human exposure to noise, heat, bio-hazards, chemicals, radiation, and improper lighting. Government standards, field measurements, work practices, engineering designs, and the effects of excessive exposure on worker health and productivity.

IE 618. Engineering Cost and Production Economics. 3 credits, 3 contact hours.
Prerequisite: IE 502 or equivalent. Cost management of operational activities. Focuses on capital investment decision making and efficient resource utilization to achieve cost-effective operations. Topics include alternative investment evaluation, budgeting activity based costing, quality costs, life cycle management and relevant behavioral science. These are considered in the context of manufacturing and service industry application.

IE 621. Systems Analysis and Simulation. 3 credits, 3 contact hours.
Prerequisites: IE 331, IE 466 (see undergraduate catalog for descriptions), or equivalent or department approval. The application of well-integrated systems approach, systems and systems engineering in the system life cycle, system design process, mathematical tools and techniques applied to systems analysis, design for operational feasibility, systems engineering management, modeling techniques including simulation, application of discrete simulation techniques to model industrial systems, design of simulation experiments using software, output data analysis.

IE 622. Simulation and Risk Analysis in Operations Management. 3 credits, 3 contact hours.
Prerequsite: IE 331 (see undergraduate catalog for description) or equivalent. Introduction to the concepts, methodologies and applictions of simulation in operations management. Foundations of simulation, Monte Carlo approaches, simulation models using spreadsheets, generating probabilistic outcomes using random number generation techniques, applying risk analysis software to spreadsheets for various decisions making. Variety of applications in operations management, finance and marketing. Software to develop models of practical operations management applications, is provided.

IE 623. Linear Programming. 3 credits, 3 contact hours.
Prerequisite: EM 602 or introductory course in operations research. Principles, methodology, and practical applications of linear programming to complex problems in production and marketing, simplex techniques, duality theory, parametric analysis, Wolfe and Dantzig's decomposition methods, ellipsoid method, and Karmakar's method.

IE 624. Heuristic Methods. 3 credits, 3 contact hours.
Prerequisites: EM 503 or equivalent. Techniques and concepts used to develop intelligent decision support systems. Application of rules called heuristics and models of reasoning to solve problems in engineering design and manufacturing. Topics include set theory, fuzzy subset theory, decision theory, logic, inference expert systems and single and multi-fault diagnostics.

IE 641. Operations Analysis. 3 credits, 3 contact hours.
Prerequisites: EM 602 and computer programming experience. Management systems and business behavior using industrial models. Special attention is given to the interaction of individual elements that make up the total system.

IE 642. Network Flows and Applications. 3 credits, 3 contact hours.
Prerequisite: EM 602 or equivalent. Theories, algorithms, computation complexity, and application of networks, shortest path, network flow, and minimum cost flow problems. Models of industrial service systems as network problems.

IE 643. Transportation Finance. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. Same as TRAN 643.

IE 644. Application of Stochastic Modeling in Systems Control. 3 credits, 3 contact hours.
Stochastic processes applied to control of various types of systems: Markov chains, queueing theory, storage theory applications to measure performance of flexible manufacturing systems, telecommunication and distributions networks and similar service systems. Knowledge of probability theory and linear algebra is essential.

IE 650. Advanced Topics in Operations Research. 3 credits, 3 contact hours.
Prerequisite: introductory course in operations research or equivalent. Current topics in deterministic models of operations research: linear programming, large scale decomposition, integer programming, dynamic programming, and nonlinear programming. Emphasis on optimization techniques for solving mathematical programming problems.

IE 651. Industrial Simulation. 3 credits, 3 contact hours.
Prerequisite: introductory course in statistics/simulation or instructor's permission. Statistical design and analysis of Monte Carlo simulation experiments from an engineering view. Examples are provided with emphasis on industrial and manufacturing applications of simulation modeling. Markovian processes simulation, random number generation, mathematical programming, heuristics and decision theory.

IE 652. Facilities Location and Plant Layout. 3 credits, 3 contact hours.
Prerequisite: introductory course in operations research or instructor's approval. Basic con-cepts of facilities location and plant layout. Quantitative and qualitative tools needed in industrial engineering, including single and multiple facilities location problems, site selections and allocation models, use of Duality theory in location and plant layout problem, and computerized layout planning.

IE 653. Facility Maintenance. 3 credits, 3 contact hours.
Prerequisite: EM 501 or equivalent. Intended for those individuals who manage the functioning and maintenance of physical facilities. Emphasis on planning and control of facilities use, maintenance, utility management, managerial control, budgets and costs, personnel administration, legal and safety, flexibility measurement, and design.

IE 655. Concurrent Engineering. 3 credits, 3 contact hours.

IE 659. Supply Chain Engineering. 3 credits, 3 contact hours.
Coordination of product manufacturing and logistic activities across the global supply chain is studied. Focus is on supply chain design, implementation, and control. Topics include transportation and distribution networks, inventory control, demand planning, materials handling and warehousing, supply chain contracts, manufacturing flexibility, product design for responsiveness, and ERP systems. Supply chain analytics concepts and relevant case studies are introduced.

IE 661. Man-Machine Systems. 3 credits, 3 contact hours.
Prerequisite: human factors engineering. Analysis of integrated man-machine systems: physical and psychological effects of systems of deterministic and conditional responses of individuals and groups, and the resulting interaction between individuals, groups, and machine systems; also current research and development pertaining to man-machine systems.

IE 662. Cognitive Engineering. 3 credits, 3 contact hours.
Prerequisite: IE 355 or equivalent. The purpose of this course will be to introduce the application of human factors and cognitive psychology principles to the user interface design of information technology, including computer systems, groupware and communications, handheld devices and Internet applications, and automatic speech recognition interfaces. The course will provide grounding in the engineering design processes used to enhance the usability of products and services, and usability testing methods used by user interface designers. Secondly, major areas and design problems in human-computer interaction and Information Technology will be covered, with real world examples. The course would be appropriate for advanced undergraduates in engineering, computer science, and psychology.

IE 664. Advanced Ergonomics. 3 credits, 3 contact hours.
Prerequisite: IE 355 or equivalent. The course covers important topics for ergonomics, including functional anatomy of the human body, work physiology and body energy expenditure, and biomechanics for people at work. Commonly used analytical tools for ergonomics will be introduced in the course.

IE 665. Applied Industrial Ergonomics. 3 credits, 3 contact hours.
Prerequisites: IE 355 (see undergraduate catalog for description) or IE 699. Introduces the fundamentals and applications of industrial ergonomics for improving equipment, tool, workplace, and job design. Engineers, as well as safety and health professionals, will benefit from the course by understanding the design principles for human operators and current issues in industrial ergonomics, and a variety of evaluating methodologies for the design.

IE 669. Human Design Factors in Engineering. 3 credits, 3 contact hours.
Prerequisite: engineering statistics. Human factors research related to workplace and equipment design and development. Capabilities and limitations of the human sensory-motor system. Design of displays and resulting interaction between individuals, groups, environments and machine systems. Current research in engineering pertaining to the man-machine interface. Not for IE students who have had an undergraduate course in human factors.

IE 670. Industrial Work Physiology. 3 credits, 3 contact hours.
Prerequisite: IE 669 or equivalent. A study of human physiological responses to industrial environmental factors emphasizing knowledge of human anatomy and physiological tolerances: skeletal, muscle, and neuromuscular systems, evaluation of physical work capacity and performance, changes in circulation and respiration during work. Semester project under the instructor's supervision is also required.

IE 672. Industrial Quality Control. 3 credits, 3 contact hours.
Prerequisite: engineering statistics. The management of quality assurance: operational and statistical principles of acceptance sampling and process control; quality problems in production lines, and introduction to total quality management concepts.

IE 673. Total Quality Management. 3 credits, 3 contact hours.
Introduces the concept of total quality management as applicable to industrial systems. Presents methods for product quality improvement. Emphasis is on prevention through quality engineering and design, and goes beyond traditional statistical process quality control. Presentation of recent methods in supplier management, quality assurance, process control, and competitor analysis. Includes Taguchi methods and quality function deployment. Description of ISO 9000 and Baldridge Award.

IE 674. Quality Maintenance and Support Systems. 3 credits, 3 contact hours.
Prerequisites: probability and statistics, IE 331 (see undergraduate catalog for description) or equivalent. Consideration of factors necessary for cost effective maintenance and support of technical operating systems. Topics discussed include service organization and management, spare parts and logistics, quality assurance, ISO9003 training. Examples from automation, computer systems, clinical engineering, power, and transportation will be used to illustrate application areas.

IE 675. Safety in Facility and Product Design. 3 credits, 3 contact hours.
Prerequisite: IE 614 or equivalent. Application of safety principles to minimize the health and safety hazards in the design and manufacture of various products. Practical techniques for, and economic ramifications of, conformance with the many statutes enacted to assure safe workplaces and products.

IE 677. Applied Statistics and Epidemiology for Hazard Analysis. 3 credits, 3 contact hours.
Prerequisite: IE 604 or equivalent. Application of statistical concepts to the field of hazard analysis including: investigation of root causes of accidents, their patterns and trends; rules for systematic data analysis; determination of commonality factors; availability and use of customized computer software.

IE 681. Interdisciplinary Seminar in Occupational Safety and Health. 1 credit, 1 contact hour.
Restriction: OSHE students, or permission of instructor. This is a required course for students who receive the trainee scholarship from the Occupational Safety and Health Engineering Program sponsored by the National Institute for Occupational Safety and Health (NIOSH). Other graduate students are also welcome and encouraged to take the interdisciplinary seminar course. Students and residents in the ERC programs will be able to participate in an interdisciplinary course with students in industrial hygiene, occupational medicine and occupational safety.

IE 682. Industrial Safety and Health Evaluation. 3 credits, 3 contact hours.
Restriction: OSHE students, or permission of instructor. This is a required course for students who receive the trainee scholarship from the Occupational Safety and Health Engineering Program sponsored by the National Institute for Occupational Safety and Health (NIOSH). Other graduate students are also welcome and encouraged to take this site visit course. Upon completion of this course, students will be able to plan and conduct a walk-through evaluation of health and safety hazards in a workplace. Students will also understand the role of occupational health and safety disciplines in the recognition and prevention of occupational injury and illness.

IE 685. Systems Safety. 3 credits, 3 contact hours.
Prerequisites: applied probability/statistics and introductory safety. Safety decision making and systems engineering applications to safety, including planning, managing and conducting system safety programs.

IE 686. Intro to Healthcare Systems. 3 credits, 3 contact hours.
This course provides a systems analysis view of healthcare services, combining economic, quality, enterprise data and activity costing perspectives. Operations, processes and activities that characterize the US Healthcare system are introduced. System costs, reimbursement methods and financial aspects in the healthcare. Focus on the application of information technologies and system engineering tools to effectively create and deliver value in the care process. Analytical tools for identifying opportunities for systems efficiency and effectiveness.

IE 687. Healthcare Enterprise Systems. 3 credits, 3 contact hours.
Prerequisite: IE 686. Provide a thorough understanding of the role of Healthcare Enterprise Systems in healthcare organizations. A detailed study of electronic health records, computerized physician order entry, and meaningful use standards. Design and implementation of enterprise level healthcare information systems, advanced desicion support tools, and process mapping methods for optimal delivery of cost effective care. Analytical and quantitative methods that can be used to evaluate healthcare business processes, determine data requirements, and plan operating procrdures.

IE 688. Healthcare Sys Perfor Modeling. 3 credits, 3 contact hours.
Prerequisite: IE 686. Presents advanced techniques and methods for modeling and evaluating the performance of healthcare systems, including operations research, and productivity analysis, and statistical analysis methods. Introduces the performance dynamics of healthcare systems, identifies key decision variables and formulates their effect on systems performance. Develop and optimize healthcare staffing models. Application of operations research methods to a wide range of healthcare scheduling, facility design and patient flow problems.

IE 699. Special Topics in Industrial Engineering. 3 credits, 3 contact hours.
Restriction: approval from the industrial engineering graduate advisor. Special course given when interest in a subject area develops. Advanced notice of topics will be given before registration.

IE 700. Master'S Project. 0 credits, 0 contact hours.

IE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in industrial engineering. A written report must be submitted to the project advisor. The student cannot register in IE 700B more than once and the incomplete (I) grade is not allowed.

IE 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisites: matriculation for the master of science degree, thesis advisor's approval, and adequate graduate courses in the field of the proposed thesis. Candidates for the degree who choose this option must submit an acceptable thesis on an approved subject that contributes to the literature of the field, and preferably aids the candidate's present or potential, career. While original research may not always result, the thesis should provide a new conclusion or application. Approval to register for the thesis must be obtained from the thesis advisor. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

IE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in industrial engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in IE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

IE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in industrial engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (IE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

IE 704. Sequencing and Scheduling. 3 credits, 3 contact hours.
Prerequisite: IE 650 or equivalent. Advanced sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems are discussed in this course. Both deterministic and stochastic scheduling models are covered in detail. Heuristics and worst case analysis for unsolvable hard scheduling problems (NP-C problem) are introduced.

IE 705. Mathematical Programming in Management Science. 3 credits, 3 contact hours.
Prerequisites: IE 623 and IE 650. An advanced study of various mathematical programming techniques such as linear and non-linear, parametric, integer, stochastic and dynamic programming. Readings and discussions emphasize mathematical advances and applications in operations research.

IE 706. A Queueing Approach to Performance Analysis. 3 credits, 3 contact hours.
Prerequisite: IE 644 or equivalent. Newly developed techniques in the area of queueing networks that play a critical role in studying several aspects of discrete event stochastic systems such as FMS, computer-aided communication systems, transportation systems and service systems.

IE 725. Independent Research. 3 credits, 3 contact hours.
Prerequisite: approval from the industrial engineering program director. Program of study prescribed and approved by student's advisor. This special course covers areas in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course.

IE 726. Independent Research II. 3 credits, 3 contact hours.

IE 753. Airport Design and Planning. 3 credits, 3 contact hours.
Prerequisite or corequisite: TRAN 610 or EM 693. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. Same as CE 753 and TRAN 753.

IE 754. Port Design and Planning. 3 credits, 3 contact hours.
Prerequisite: TRAN 610 or EM 693. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. Same as CE 754 and TRAN 754.

IE 760. Quantitative Methods in Human Factors. 3 credits, 3 contact hours.
Prerequisite: IE 661. More advanced human factors engineering concepts analyzed quantitatively: systems modeling, control theory, human error, and decision making. Discussion of human factors, research design and data analysis. Operator/computer interaction is also emphasized.

IE 761. Advanced Studies in Human Factors. 3 credits, 3 contact hours.
Prerequisite: one year of graduate work in human factors or the equivalent. The course integrates various areas of graduate studies in human factors such as: work physiology, occupational safety, environment and human-machine systems. Detailed discussion of selected current papers covering theoretical review, experimental design, results, applications, and future research. Completion of semester project under instructor's guidance is mandatory.

IE 762. Psychophysical Methods in Human Factors. 3 credits, 3 contact hours.
Prerequisite: one year of graduate work in human factors or instructor's approval. This course considers various classical and modern psychophysical methods, signal detection theory, information theory, and human information processing applicable to advanced human factors/occupational safety research measurement and normative modeling.

IE 790. Doctoral Dissertation. 0 credits, 0 contact hours.

IE 790A. Doctoral Dissertation. 1 credit, 1 contact hour.

IE 790B. Doctoral Dissertation. 3 credits, 3 contact hours.

IE 790C. Doc Dissertation & Res. 6 credits, 3 contact hours.

IE 790D. Doc Dissertation & Res. 9 credits, 3 contact hours.

IE 790E. Doc Dissertation & Res. 12 credits, 3 contact hours.

IE 790F. Doct Dissertation & Res. 15 credits, 0 contact hours.

IE 790G. Doctoral Dissertation. 18 credits, 0 contact hours.

IE 791. Graduate Seminar. 0 credits, 0 contact hours.
A seminar in which faculty or others present summaries of advanced topics suitable for research. Discussion of research procedures, thesis organization, and content. Students engaged in research will present their own research for discussion and criticism.

IE 792B. Pre Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: IE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in industrial engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ME 590. Graduate Co-op Work Experience I. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Cooperative education internship providing on-the-job reinforcement of academic programs in mechanical engineering. Work assignments and projects are developed by the co-op office in consultation with the mechanical engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in mechanical engineering. Course cannot be used for mechanical engineering degree credit.

ME 591. Graduate Co-op Work Experience II. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

ME 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

ME 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisite: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

ME 607. Advanced Thermodynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate thermodynamics. Basic laws of thermodynamics are applied to various thermodynamic systems. Topics include: availability, stability requirements, equation of state, property relations, properties of homogeneous mixtures, optimization applied to power generation and refrigeration cycles, and thermodynamic design of system components.

ME 608. Non-Equilibrium Thermodynamics. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics and heat transfer, and ME 616. (May be taken concurrently.) Principles and mathematical techniques of non-equilibrium thermodynamics applied to mechanical engineering problems. Topics include field theory, energy and entropy balances, variational principles, and applications to fluid flow, heat exchangers and combustion.

ME 609. Dynamics of Compressible Fluids. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, fluid mechanics, and thermodynamics. One-dimensional reversible and irreversible compressible fluid flow, including effects of variable area, friction, mass addition, heat addition, and normal shock; two-dimensional reversible subsonic and supersonic flows, and an introduction to the method of characteristics and two-dimensional oblique shock.

ME 610. Applied Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: undegraduate fluid mechanics, thermodynamics, heat transfer and differential equations. Fundamentals of conduction, convection and radiation heat transfer. Practical engineering applications of heat exchangers including the design approaches by Mean Temperature Difference and Effectiveness-NTU methods, fins, convection fouling factors, and variable property analysis.

ME 611. Dynamics of Incompressible Fluids. 3 credits, 3 contact hours.
Prerequisites: undergraduate fluid mechanics and ME 616. (May be taken concurrently.) An introduction to the hydrodynamics of ideal fluids; two-dimensional potential flow and stream functions; conformal mapping; and differential equations of viscous flow. Boundary layer theory and dimensional analysis are introduced.

ME 612. Gas Dynamics. 3 credits, 3 contact hours.
Prerequisite: ME 616. (May be taken concurrently.) Physical phenomena of gas dynamics and mathematical methods and techniques needed for analysis. Dynamic and thermodynamic relations for common flow situations are described through vector calculus. The nonlinearity of resulting equations and solutions such as numerical analysis, linearization or small perturbation theory, transformation of variables, and successive approximations are discussed. The method of characteristics is reviewed in detail for shock flows.

ME 613. Radiation Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, thermodynamics, heat transfer and ME 616. (May be taken concurrently.) Heat radiation of solid bodies, gases and flames; angle factors; radiative properties of electrical conductors and non-conductors; application of radiative networks to multi-body problems; diffuse specular reflectors: artificial satellites and space vehicles; analogy between heat transfer by radiation and electrical networks; and combined conduction and radiation problems.

ME 614. Continuum Mechanics. 3 credits, 3 contact hours.
Prerequisites: Undergraduate courses in mechanics, fluid mechanics, solid mechanics, and mathematics (linear algebra, differential equations, and vector calculus) or approval of the instructor. Fundamentals of the mechanics of continuous media. Specific topics include vector and tensor analysis; kinematics associated with finite deformation; the stress tensor; and the conservation laws of mass, linear momentum, angular momentum, and energy. Constitutive equations for linear and non-linear elastic solids and for inviscid and Newtonian fluids are discussed. The role of material invariance under superimposed rigid body motion and material symmetry in the formulation of appropriate constitutive equations are emphasized.

ME 615. Advanced Mechanical Vibrations. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and system dynamics. One-, Two- and Multiple degree of freedom systems, Lagrange's equation of motion, Runge-Kutta computation, Finite Element Method and classical methods for normal mode analysis, matrix notation and iteration procedure, and Fourier series representation for the solution of vibration problems.

ME 616. Matrix Methods in Mechanical Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate differential equations. Applications of matrix algebra and matrix calculus to engineering analysis; matrix methods in solid and fluid mechanics; vibration, elasticity, viscous fluids, and heat transfer. Matrix theory is used to show the basic unity in engineering analysis.

ME 618. Selected Topics in Mechanical Engineering. 3 credits, 3 contact hours.
Prerequisite: departmental approval. Given when interest develops. Topics may include analysis and/or design of energy or mechanical systems of current interest to mechanical engineers.

ME 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy, near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

ME 620. Mechanics of Materials. 3 credits, 3 contact hours.
Prerequisites: Undergraduate differential equations and mechanics of materials or linear elasticity. Governing equations and other balance laws; stress and strain distributions in solids subjected to various loading conditions; posing and solving boundary value problems for isotropic linear elastic solids; instabilities and other failure modes of linear elastic solids; and numerical techniques to solve the governing equations.

ME 621. Advanced Mechanics of Material. 3 credits, 3 contact hours.
Prerequisites: ME 620. ME 614 is strongly recommended Governing equations and other balance laws for the mechanics of solids; large deformation kinematics and non-linear material behavior; advanced constitutive models for solids; fundamentals of fracture mechanics; numerical techniques for the solution of non-linear solid mechanics problems.

ME 622. Finite Element Methods in Mechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and strength of materials. Using variational formulation and Ritz approximation, element equations for bar, beam, potential flow, heat transfer, torsion of a solid bar and plane elasticity problems are derived and solved with computer programs.

ME 624. Microlevel Modeling in Particle Technology. 3 credits, 3 contact hours.
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first part concerns the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. Same as CHE 625.

ME 625. Introduction to Robotics. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, kinematics and demonstrated competence in computer programming and ME 616. (May be taken concurrently.) Introduction to robotics, and computer-controlled programmable robotic manipulators; robot geometries; kinematics of manipulators; differential motion; work space planning and trajectory control; dynamics; robot sensing, and robot programming.

ME 626. Fatigue Fracture of Solids. 3 credits, 3 contact hours.
A comprehensive introduction to the linear elastic fracture mechanics covering the basics of linear elasticity, crack-tip stress, displacement, and strain fields; energetics of fracture; and fracture toughness testing. This will be followed by a brief introduction to plasticity and elastic-plastic fracture parameters such as J-integral. The state-of-the-art in fracture mechanics, such as cohesive zone models and fracture of emerging materials (e.g., battery materials), will be discussed along with the mechanisms of fracture and toughening in various materials. The course will include assignments and a group project where students undertake critical review of a peer reviewed journal paper on a fracture topic (approved by instructor).

ME 628. Machine Vision Principles and Applications. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and demonstrated competence in computer programming. Fundamentals of machine vision as applied to inspection, recognition, and guidance in mechanical and manufacturing processes. Emphasis on real-time machine vision algorithms for machine parts inspection and identification. Topics include lighting and optics, camera selection and calibration, image segmentation, edge detection, feature extraction, and pattern classification.

ME 630. Analytical Methods in Machine Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, machine design, and ME 616. (May be taken concurrently.) Theory and analytical methods used in machine design. Comparisons are made between approximate and exact engineering methods for evaluation of the range of applicability of solutions. Topics include advanced analysis of threaded members; keyed, splined, and shrink fits when subjected to torque; preloaded bearings; surging, presetting and buckling of coiled springs; and accurate analysis of impact stresses and stresses beyond the yield point.

ME 631. Bearings and Bearing Lubrication. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, machine design and ME 616. (May be taken concurrently.) The theoretical and physical aspects of lubrication: hydrostatic and hydrodynamic problems. Reynold's differential equation for pressure distribution applied to slider bearing and journal bearing problems with and without end leakage.

ME 632. Mechanical Engineering Measurements. 3 credits, 3 contact hours.
This course offers extensive mechanical engineering lab experience, including measurement fundamentals, hands-on experiments, uncertainty analysis, technique comparison, and professional engineering reports. It also focuses on the fundamental principles behind each methodology and relevant applications. The topics cover measurement in major mechanical engineering areas including thermodynamics, thermofluids, and control. Specialized experiments include fluidization, CAD/CAM, and NC machining. Comparisons of experimental results against theoretical or computational results are also required.

ME 633. Dynamics of Machinery. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and matrix analysis. Consideration of kinematics, constraints and Jacobians, linear and angular momentum and potential energy and conservative forces of mechanical systems. Application of principle of virtual work, D?Alembert's principle, method of virtual power and Lagrange's equation to systems of particles and systems of rigid bodies.

ME 635. Computer-Aided Design. 3 credits, 3 contact hours.
Prerequisites: undergraduate linear algebra (matrices operation) and differential equations. Adaptation of computer for solving engineering design problems; design morphology; simulation and modeling; algorithms; problem-oriented languages; use of available software; computer graphics, and automated design.

ME 636. Mechanism Design: Analysis and Synthesis. 3 credits, 3 contact hours.
Prerequisites: undergraduate kinematics, dynamics and demonstrated competence in computer programming and ME 616. (May be taken concurrently.) Kinematic principles combined with computer-assisted methods for designing mechanisms; complex polar notation; and dynamic and kinetostatic analysis of mechanisms. Kinematic synthesis of planar mechanisms; graphical Burmester theory for plane linkage synthesis; and planar linkage synthesis for function and path generation.

ME 637. Kinematics of Spatial Mechanisms. 3 credits, 3 contact hours.
Prerequisites: undergraduate kinematics, dynamics, knowledge of matrices and ME 616. (May be taken concurrently.) Advanced techniques for the dual-number coordinate-transformation matrix modeling to perform the displacement, velocity, static and dynamic force analysis of spatial mechanisms. Applications considered will include shaft couplings, skew four-bars, wobble plates, generalized slider-cranks and robotic manipulators.

ME 638. Computer-Aided Machining. 3 credits, 3 contact hours.
Prerequisites: demonstrated competence in computer programming, ME 305, ME 616 and ME 635 or equivalent. Introduction of computer applications to understand integrated computer-aided machining process. Included in the course are the fundamentals of motion control and NC/CNC/DNC machining, part programming and post-processors, and advances in CAM. Student projects are carried out using appropriate manufacturing software.

ME 641. Refrigeration and Air Conditioning. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations, fluid mechanics and thermodynamics. Refrigeration and air conditioning cycles; comfort analysis, psychometric chart analysis, heat and mass transfer steady and transient processes, heating and cooling design loads, energy loads and standards requirements.

ME 643. Combustion. 3 credits, 3 contact hours.
Prerequisites: Undergraduate thermodynamics & fluid mechanics. Chemical & physical process of combustion: ideal combustion, actual combustion, mass balance, energy of reaction, maximum adiabatic combustion temperature, chemical equilibrium, heating values of fuels, combustion in furnaces, internal combustion engines & other heat engines, with emphasis on the analysis & control of the products of combustion in light of environmental considerations.

ME 644. Building Environmental Control Principles. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, fluid mechanics, heat transfer and differential equations. Control systems for buildings including control of temperature, moisture and air quality. Optimization of systems for control of building energy use. Modern microprocessor-based control systems, including direct digital control, proportional and integral controllers, predictive control, adaptive control, optimum start controllers and optimal control.

ME 653. Control of Electro-Mechanical Networks. 3 credits, 3 contact hours.
Prerequisites: undergraduate electrical circuits and mechanical vibrations or equivalent. Electro-mechanical systems; control loops; use of mechanical networks in dynamic systems; and stability and response to various inputs in electro-mechanical networks.

ME 655. Introduction to Modern Control Methods. 3 credits, 3 contact hours.
Prerequisites: undergraduate system dynamics and automatic controls. Introduction to modern control methods applied to mechanical and manufacturing systems. Topics include state variable feedback, observer theory, nonlinear control, optimal control, and adaptive control for both continuous and discrete systems.

ME 660. Noise Control. 3 credits, 3 contact hours.
Prerequisites: undergraduate differential equations and physics. Engineering methods for reducing noise pollution; reduction of intensity at the source; limitation of transmission paths and absorption; application to structures, machinery, ground transportation, aircraft, and noise measurement.

ME 670. Introduction to Biomechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment.

ME 671. Biomechanics of Human Structure and Motion. 3 credits, 3 contact hours.
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

ME 675. Mechanics of Fiber Composites. 3 credits, 3 contact hours.
Prerequisites: ME 315 (see undergraduate catalog for course description) and demonstrated competence in computer programming. Introduces various design problems using fiber composites. Analysis of general fiber composite laminate and short fiber composites, fracture mechanics, fatigue, creep and viscoelasticity, thermal stresses, special layups and associated optimization problems.

ME 676. Applied Plasticity. 3 credits, 3 contact hours.
Prerequisite: ME 620 or equivalent. Fundamentals of plasticity applied to mechanical and manufacturing engineering problems. Topics include elastic-plastic analysis for beams, rings and plates. Plastic instability and slip-line fields are considered.

ME 678. Engineering Design of Plastic Products. 3 credits, 3 contact hours.
Prerequisite: Knowledge of Pro/Engineer (or IDEAS). Structure and properties of plastics including stress-strain behavior and the effect of fillers and reinforcements. Designing for impact, flexure, shear, friction, puncture, creep and fatigue. Case studies of structural, electrical, and optical applications.

ME 679. Polymer Processing Techniques. 3 credits, 3 contact hours.
Prerequisites: undergraduate courses in fluid dynamics and heat transfer. Techniques for processing of plastics: extrusion, injection molding, compression molding, thermoforming, casting.

ME 680. Polymer Processing Equipment. 3 credits, 3 contact hours.
Prerequisites: CHE 645 or equivalent and undergraduate heat transfer. Application of heat transfer, fluid mechanics, and thermodynamics to the design and control of polymer processing equipment. Detailed consideration of extrusion, collandering, rotational molding, stamping, and injection molding.

ME 700. Master'S Project. 0 credits, 0 contact hours.
Prerequisite: department approval. An extensive paper involving design, construction, and analysis, or theoretical investigation. Further information may be obtained from the graduate advisor.

ME 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. A written report must be submitted to the project advisor. The student cannot register in ME 700B more than once and the incomplete (I) grade is not allowed.

ME 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: department approval. Projects involving design, construction, experimental, or theoretical investigation carried out under the supervision of a designated member of the mechanical engineering faculty. The completed written thesis must be defended in a publicly announced oral defense. A student must register for a minimum of 3 credits per semester until completion, although degree credit will be limited to the 6 credits indicated for the thesis.

ME 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in ME 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ME 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (ME 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

ME 710. Conduction Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: ME 610 and ME 616 or equivalent. Heat transfer by conduction: differential and integral forms of the energy equation for isotropic and anisotropic material. Analytical and numerical studies of transient and steady one-, two-, and three-dimensional heat transfer problems for a variety of boundary conditions including phase change. In addition, variational and boundary element methods are applied to heat conduction problems.

ME 711. Convection Heat Transfer. 3 credits, 3 contact hours.
Prerequisites: ME 610 and ME 616 or equivalent. Development of convective heat transfer theory: currently available methods, analytical and numerical, for predicting heat rates in forced, natural, and mixed convection in laminar and turbulent flow regimes are thoroughly studied. Studied techniques are applied to the thermal design of complex systems.

ME 712. Mechanics of Viscous Fluids. 3 credits, 3 contact hours.
Prerequisites: ME 611 and ME 616. (May be taken concurrently.) Properties and behavior of real fluids in laminar and turbulent motion. Review of tensor analysis; current mathematical and empirical laws and methods; flows in ducts; exact solutions of Navier-Stokes equations; boundary layers over surfaces and flow past bodies.

ME 713. Non-Newtonian Fluid Dynamics. 3 credits, 3 contact hours.
Prerequisites: ME 611, ME616. Review of Newtonian fluid mechanics. Time dependent response and transport properties of non-Newtonian fluids in simple shear and extensional flows. Experimental techniques for measuring dynamic response and transport properties. Continuum and micromechanical constitutive models; solutions of constitutive equations.

ME 714. Principles of Particulate Multiphase Flows. 3 credits, 3 contact hours.
Prerequisite: Courses in fluid mechanics or approval of the instructor. This course provides an introduction to the fundamental principles of mass, momentum and heat transfer in particulate multiphase flows. Theories and governing equations for distinctive responses and motions of each phase and the dynamic interactions among phases are formulated. Typical industrial applications will be illustrated.

ME 717. Selected Topics in Mechanical Engineering I. 3 credits, 3 contact hours.
Prerequisite: department approval. Given when interest develops. Topics may include advanced mechanisms, aerodynamics, analysis of ME systems, design optimization, and case studies in design.

ME 718. ST:. 3 credits, 3 contact hours.

ME 721. Thermal Stresses. 3 credits, 3 contact hours.
Prerequisites: vector analysis or ME 616 or equivalent and theory of elasticity or ME 785. Thermoelasticity; reduction of thermoelastic problems to constant temperature equivalents; fundamentals of heat transfer; and elastic and inelastic stress analysis.

ME 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

ME 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for ME 726 if they have taken ME 725 in a prior semester.

ME 727. Independent Study III. 3 credits, 3 contact hours.
Prerequisites: written permission from department chairperson plus prerequisite courses prescribed by a supervising faculty member. Areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering. A maximum of two independent studies courses may be applied to a degree.

ME 735. Advanced Topics in Robotics. 3 credits, 3 contact hours.
Prerequisite: ME 625. Introduction to advanced topics and techniques in robotics. Subjects covered include differential kinematics, calibration and accuracy, trajectory control, and compliant motion control as well as an in-depth treatment of topics discussed in ME 625.

ME 736. Advanced Mechanism Design. 3 credits, 3 contact hours.
Prerequisites: ME 636 and ME 616. Advanced methods for the synthesis of mechanisms. Topics include synthesis of planar mechanisms for three, four and five positions, multiloop linages, change of branch and order problems, and optimal synthesis of mechanisms. Synthesis of linkages for special types of motion including straight line motion, cusp points on coupler curves and adjustable mechanisms.

ME 738. Computer Aided Engineering. 3 credits, 3 contact hours.
Prerequisites: ME 635. This course covers advanced CAD and CAE tools for visual computing simulation and analysis. Topics include modeling, assembly, CAD data exchange by exporting and importing various CAD model formats, computer simulation and analysis of structure, thermal, fluid and animation of the results of analysis. Multi-physics analyses such as thermal-structure, electric-thermal-structure in MEMS and fluid-structure interactions are studied. The laboratory component involves use of most current commercial CAD/CAE software packages.

ME 752. Design of Plates and Shells. 3 credits, 3 contact hours.
Prerequisites: ME 616 or equivalent and ME 620. A study of plates and shells. Mechanical engineering design solutions for typical loading and boundary conditions through analytical and numerical methods. Plate and shell interfaces and vibration are also considered.

ME 754. Pressure Vessel Design. 3 credits, 3 contact hours.
Prerequisites: ME 616 or equivalent and ME 620. Theories in designing pressure vessels; analysis of circular plates; cylindrical and spherical shells; pressure vessel heads; pipe bends; and attachments. Consideration is also given to pressure vessel materials in fatigue and creep designs.

ME 755. Adaptive Control Systems. 3 credits, 3 contact hours.
Prerequisite: ME 655. Theory and application of self-tuning and model reference adaptive control for continuous and discrete-time deterministic systems. Topics include model-based methods for estimation and control, stability of nonlinear systems and adaptive laws. Applications of adaptive control in mechanical systems and manufacturing processes.

ME 785. Theory of Deformable Solids in Mechanical Engineering I. 3 credits, 3 contact hours.
Prerequisites: ME 616 or equivalent and ME 620. Measure of strain; strain tensor; stress tensor; equilibrium equations; constitutive relations; compatibility conditions; conditions for and formulation of three-dimensional problems; and the relationship of engineering theories for beams, plates, and shells to the equations of elasticity.

ME 786. Theory of Deformable Solids in Mechanical Engineering II. 3 credits, 3 contact hours.
Prerequisite: ME 785. Solutions for problems formulated in ME 785 eigenfunction solutions; operational methods; complex variables theory; three-dimensional problems; contact problems; wave propagation; and non-linear problems.

ME 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Required of all students working toward the Doctor of Philosophy in Mechanical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached and for 3 credits each semester thereafter.

ME 790A. Doc Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: ME 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in ME 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

ME 790B. Doc Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: ME 791. Since the ME 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

ME 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite: ME 791. Since the ME 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and/or theoretical investigation of a relevant topic in mechanical engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities).

ME 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

ME 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

ME 790F. Doctoral Diss & Research. 15 credits, 3 contact hours.

ME 790G. Doctoral Dissertation. 18 credits, 3 contact hours.

ME 791. Graduate Seminar and Professional Presentations. 0 credits, 0 contact hours.
Regular attendance required of all students in the Mechanical Engineering PhD program. Each PhD student is required to make a 15 minute presentation on a topic related to the student's research with an additional 10 minutes to address audience questions. The seminar participants eveluate each speaker.

ME 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: ME 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in mechanical engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

ME 792C. Pre-Doctoral Research. 6 credits, 6 contact hours.

ME 792D. Pre Doctoral Research. 9 credits, 3 contact hours.

ME 794. Mechanical Engineering Colloquium. 0 credits, 1 contact hour.
Prerequisites: graduate standing and major in mechanical engineering. National and international experts in mechanical engineering discuss their recent research. Required of all students enrolled in mechanical engineering graduate degree programs. Students must register in this course for at least two semesters and attend at least four lectures in each semester. All doctoral students and students with assistantships must register in this course each semester and attend regularly.

M.S. in Engineering Management

Degree Requirements

Students who lack appropriate academic preparation may be required to take bridge courses in the areas of statistics, cost analysis and engineering economics.

The program requires 30 credits, 18 of which are taken in a required core. A purpose of the core is to provide knowledge in the functional areas that are the cornerstones of the discipline: organization and people management, cost management, and systems management. The remaining 12 credits are elective courses, which may be within an area of specialization to meet the individual's specific professional and personal objectives. A 3-credit project (IE 700 Master'S Project) or a 6-credit thesis (IE 701 Master'S Thesis) are optional electives. In some cases, students may select courses to enhance their technical competency. In other cases, individuals may select courses to prepare for a change in responsibilities or job function. At least half of the elective courses must be selected from those having an IE or EM prefix.

M.S. in Engineering Management (courses only)

Code	Title	Credits
Core Courses		
ACCT 615	Management Accounting	3
EM 602	Management Science	3
EM 636	Project Management	3
HRM 601	Organizational Behavior	3
IE 673	Total Quality Management	3
MIS 645	Information Systems Principles	3
Electives [1]		
Select four of the following:		12
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 637	Project Control	
EM 691	Cost Estimating for Capital Projects	
IE 651	Industrial Simulation	
IE 659	Supply Chain Engineering	
EM 632	Legal Aspects in Construction	
IE 618	Engineering Cost and Production Economics	
IE 621	Systems Analysis and Simulation	
EM 640	Distribution Logistics	

EM 641	Engineering Procurement and Materials Management	
EM 674	Benchmarking and Quality Function Deployment	
IE 605	Engineering Reliability	
IE 672	Industrial Quality Control	
MNE 654	Design for Manufacturability	
EM 632	Legal Aspects in Construction	
IE 653	Facility Maintenance	
MNE 601	Computerized Manufacturing Systems	
MNE 602	Flexible and Computer Integrated Manufacturing	
MNE 655	Concurrent Engineering	
EM 655	Management Aspects of Information Systems	
IE 661	Man-Machine Systems	
EM 635	Management of Engineering Research and Development	
Total Credits		30

[1] School of Management courses with a FIN, MRKT, MIS, HRM or MGMT prefix may be taken as electives

M.S. in Engineering Management (Master's project)

Code	Title	Credits
Core Courses		
ACCT 615	Management Accounting	3
EM 602	Management Science	3
EM 636	Project Management	3
HRM 601	Organizational Behavior	3
IE 673	Total Quality Management	3
MIS 645	Information Systems Principles	3
Project		
EM 700B	Master's Project	3
Electives [1]		
Select three of the following:		9
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 637	Project Control	
EM 691	Cost Estimating for Capital Projects	
IE 651	Industrial Simulation	
IE 659	Supply Chain Engineering	
EM 632	Legal Aspects in Construction	
IE 618	Engineering Cost and Production Economics	
IE 621	Systems Analysis and Simulation	
EM 640	Distribution Logistics	
EM 641	Engineering Procurement and Materials Management	
EM 674	Benchmarking and Quality Function Deployment	
IE 605	Engineering Reliability	
IE 672	Industrial Quality Control	
MNE 654	Design for Manufacturability	
EM 632	Legal Aspects in Construction	
IE 653	Facility Maintenance	
MNE 601	Computerized Manufacturing Systems	
MNE 602	Flexible and Computer Integrated Manufacturing	
MNE 655	Concurrent Engineering	
EM 655	Management Aspects of Information Systems	
IE 661	Man-Machine Systems	

EM 635	Management of Engineering Research and Development	
Total Credits		30

[1] School of Management courses with a FIN, MRKT, MIS, HRM or MGMT prefix may be taken as electives

M.S. in Engineering Management (Master's thesis)

Code	Title	Credits
Core Courses		
ACCT 615	Management Accounting	3
EM 602	Management Science	3
EM 636	Project Management	3
HRM 601	Organizational Behavior	3
IE 673	Total Quality Management	3
MIS 645	Information Systems Principles	3
Thesis		
EM 701B & 701B	Master's Thesis and Master's Thesis	6
or EM 701C	Master's Thesis	
Electives [1]		
Select two of the following:		6
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 637	Project Control	
EM 691	Cost Estimating for Capital Projects	
IE 651	Industrial Simulation	
IE 659	Supply Chain Engineering	
EM 632	Legal Aspects in Construction	
IE 618	Engineering Cost and Production Economics	
IE 621	Systems Analysis and Simulation	
EM 640	Distribution Logistics	
EM 641	Engineering Procurement and Materials Management	
EM 674	Benchmarking and Quality Function Deployment	
IE 605	Engineering Reliability	
IE 672	Industrial Quality Control	
MNE 654	Design for Manufacturability	
EM 632	Legal Aspects in Construction	
IE 653	Facility Maintenance	
MNE 601	Computerized Manufacturing Systems	
MNE 602	Flexible and Computer Integrated Manufacturing	
MNE 655	Concurrent Engineering	
EM 655	Management Aspects of Information Systems	
IE 661	Man-Machine Systems	
EM 635	Management of Engineering Research and Development	
Total Credits		30

[1] School of Management courses with a FIN, MRKT, MIS, HRM or MGMT prefix may be taken as electives

Students may also have graduate courses in their undergraduate engineering degree or other technical discipline.

M.S. in Healthcare Systems Management

Degree Requirements

A minimum of 30 credits beyond a baccalaureate degree is required. A master's thesis or independent research is optional.

M.S. in Healthcare Systems Management (courses only)

Code	Title	Credits
Core Courses		
IE 699	Special Topics in Industrial Engineering	3
IE 699	Special Topics in Industrial Engineering	3
EM 602	Management Science	3
EM 636	Project Management	3
HRM 601	Organizational Behavior	3
IE 604	Advanced Engineering Statistics	3
Electives		
Select four of the following:		12
IE 699	Special Topics in Industrial Engineering	
EM 637	Project Control	
IE 682	Industrial Safety and Health Evaluation	
IE 672	Industrial Quality Control	
IE 650	Advanced Topics in Operations Research	
IE 621	Systems Analysis and Simulation	
IE 673	Total Quality Management	
MIS 648	Decision Support Systems for Managers	
MGMT 620	Management of Technology	
Total Credits		30

M.S. in Healthcare Systems Management (independent research)

Code	Title	Credits
Core Courses		
IE 699	Special Topics in Industrial Engineering	3
IE 699	Special Topics in Industrial Engineering	3
EM 602	Management Science	3
EM 636	Project Management	3
HRM 601	Organizational Behavior	3
IE 604	Advanced Engineering Statistics	3
Independent Research		
IE 725	Independent Research	3
Electives		
Select three of the following:		9
IE 699	Special Topics in Industrial Engineering	
EM 637	Project Control	
IE 682	Industrial Safety and Health Evaluation	
IE 672	Industrial Quality Control	
IE 650	Advanced Topics in Operations Research	
IE 621	Systems Analysis and Simulation	
IE 673	Total Quality Management	
MIS 648	Decision Support Systems for Managers	
MGMT 620	Management of Technology	
Total Credits		30

M.S. in Healthcare Systems Management (Master's thesis)

Code	Title	Credits
Core Courses		
IE 699	Special Topics in Industrial Engineering	3
IE 699	Special Topics in Industrial Engineering	3
EM 602	Management Science	3

EM 636	Project Management	3
HRM 601	Organizational Behavior	3
IE 604	Advanced Engineering Statistics	3
Thesis		
IE 701B & 701B	Master's Thesis and Master's Thesis	6
or IE 701C	Master's Thesis	
Electives		
Select two of the following:		6
IE 699	Special Topics in Industrial Engineering	
EM 637	Project Control	
IE 682	Industrial Safety and Health Evaluation	
IE 672	Industrial Quality Control	
IE 650	Advanced Topics in Operations Research	
IE 621	Systems Analysis and Simulation	
IE 673	Total Quality Management	
MIS 648	Decision Support Systems for Managers	
MGMT 620	Management of Technology	
Total Credits		30

M.S. in Industrial Engineering

Degree Requirements

Students who do not have a bachelor of science degree in industrial engineering may be admitted and required to complete the bridge program. Bridge courses do not count toward degree requirements.

A minimum of 30 credits beyond a baccalaureate degree is required. A master's thesis or independent research is optional. Students select an area of specialization and individually design their programs in consultation with the graduate advisor. Faculty advisor approval must be obtained by students before they are permitted to register for IE 701 Master'S Thesis.

Seminar: In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

M.S. in Industrial Engineering (courses only)

Code	Title	Credits
Bridge Courses		
EM 502	Engineering Cost Analysis	3
EM 602	Management Science	3
IE 501	Fundamentals of Industrial Engineering	3
Total Credits		9

Code	Title	Credits
Core Courses		
IE 604	Advanced Engineering Statistics	3
IE 618	Engineering Cost and Production Economics	3
IE 621	Systems Analysis and Simulation	3
IE 650	Advanced Topics in Operations Research	3
Areas of Specialization		
Select three of the following: [1]		9
Quality Systems Engineering		
IE 672	Industrial Quality Control	
IE 673	Total Quality Management	
MNE 654	Design for Manufacturability	
Operations Research		

IE 651	Industrial Simulation	
IE 704	Sequencing and Scheduling	
IE 650	Advanced Topics in Operations Research	
Information Systems Design		
CS 610	Data Structures and Algorithms	
CS 631	Data Management System Design	
EM 655	Management Aspects of Information Systems	
Supply Chain & Logistics		
IE 642	Network Flows and Applications	
IE 699	Special Topics in Industrial Engineering	
Service Systems Engineering		
IE 651	Industrial Simulation	
MIS 648	Decision Support Systems for Managers	
Total Credits		21

[1] Students may choose to specialize in any one of the following areas. Completion of all three courses in a specialization will qualify the student for a specialization certificate to be issued by the department. This will be awarded in conjunction with successful completion of the MS degree.

M.S. in Industrial Engineering (independent research)

Code	Title	Credits
Bridge Courses		
EM 502	Engineering Cost Analysis	3
EM 602	Management Science	3
IE 501	Fundamentals of Industrial Engineering	3
Total Credits		9

Code	Title	Credits
Core Courses		
IE 604	Advanced Engineering Statistics	3
IE 618	Engineering Cost and Production Economics	3
IE 621	Systems Analysis and Simulation	3
IE 650	Advanced Topics in Operations Research	3
Independent Research		
IE 725	Independent Research	3
Areas of Specialization		
Select three of the following: [1]		9
Quality Systems Engineering		
IE 672	Industrial Quality Control	
IE 673	Total Quality Management	
MNE 654	Design for Manufacturability	
Operations Research		
IE 651	Industrial Simulation	
IE 704	Sequencing and Scheduling	
IE 650	Advanced Topics in Operations Research	
Information Systems Design		
CS 610	Data Structures and Algorithms	
CS 611	Introduction to Computability and Complexity	
EM 655	Management Aspects of Information Systems	
Supply Chain & Logistics		
IE 642	Network Flows and Applications	
IE 699	Special Topics in Industrial Engineering	
Service Systems Engineering		
IE 651	Industrial Simulation	

MIS 648	Decision Support Systems for Managers	
Total Credits		24

[1] Students may choose to specialize in any one of the following areas. Completion of all three courses in a specialization will qualify the student for a specialization certificate to be issued by the department. This will be awarded in conjunction with successful completion of the MS degree.

M.S. in Industrial Engineering (Master's thesis)

Code	Title	Credits
Bridge Courses		
EM 502	Engineering Cost Analysis	3
EM 602	Management Science	3
IE 501	Fundamentals of Industrial Engineering	3
Total Credits		9

Code	Title	Credits
Core Courses		
IE 604	Advanced Engineering Statistics	3
IE 618	Engineering Cost and Production Economics	3
IE 621	Systems Analysis and Simulation	3
IE 650	Advanced Topics in Operations Research	3
Thesis		
IE 701B & 701B	Master's Thesis and Master's Thesis	6
or IE 701C	Master's Thesis	
Areas of Specialization		
Select three of the following: [1]		9
Quality Systems Engineering		
IE 672	Industrial Quality Control	
IE 673	Total Quality Management	
MNE 654	Design for Manufacturability	
Operations Research		
IE 651	Industrial Simulation	
IE 704	Sequencing and Scheduling	
IE 650	Advanced Topics in Operations Research	
Information Systems Design		
CS 610	Data Structures and Algorithms	
CS 611	Introduction to Computability and Complexity	
EM 655	Management Aspects of Information Systems	
Supply Chain & Logistics		
IE 642	Network Flows and Applications	
IE 699	Special Topics in Industrial Engineering	
Service Systems Engineering		
IE 651	Industrial Simulation	
MIS 648	Decision Support Systems for Managers	
Total Credits		27

[1] Students may choose to specialize in any one of the following areas. Completion of all three courses in a specialization will qualify the student for a specialization certificate to be issued by the department. This will be awarded in conjunction with successful completion of the MS degree.

M.S. in Manufacturing Systems Engineering

The curriculum for this major is currently under review and will be made available after September 30, 2019.

M.S. in Mechanical Engineering

Degree Requirements

Students who lack appropriate undergraduate preparation may be admitted and are asked to make up deficiencies by taking a program of bridge courses that is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements and may include undergraduate courses.

The Master of Science in Mechanical Engineering program offers three areas of specialization.

1. *CAD/CAM, Mechanisms & Control* - computer aided engineering, mechanisms, biomechanical & medical devices, robotics and controls.
2. *Mechanics & Material Processing* - tissues & biomechanics, continuum mechanics, plastics, micro/nano materials, particle technology.
3. *Thermo-Fluid Systems & Energy* - biofluids, computational & multiphase fluid dynamics, granular science, HVAC, energy.

The student consults the graduate advisor to plan and develop an individualized and cohesive sequence of courses that meet program requirements of at least 30 degree credits.The MS degree students opting for the project or thesis option must make an arrangement with a faculty member for supervision and obtain the departmental approval in order to receive permits to register for the proper section. Students opting for a project must register for the M.S. project (ME 700) for 3 credits. Students opting for a thesis must register for the M.S. thesis (ME 701) for 6 credits and successfully defend the thesis before graduation. Thesis option is required of all students who receive departmental or research-based awards.

Seminar: In addition to the minimum 30 degree credits required, every student must take a minimum of two semesters of ME 794 Mechanical Engineering Colloquium. Students who receive departmental or research-based awards must enroll every semester in ME 794 Mechanical Engineering Colloquium.

M.S. in Mechanical Engineering (courses only)

Code	Title	Credits
Required Courses		
ME 616	Matrix Methods in Mechanical Engineering	3
or MATH 651	Methods of Applied Mathematics I	
Select three of the following:		9
ME 610	Applied Heat Transfer	
ME 611	Dynamics of Incompressible Fluids	
ME 614	Continuum Mechanics	
ME 620	Mechanics of Materials	
ME 632	Mechanical Engineering Measurements	
ME 635	Computer-Aided Design	
Elective ME Graduate Courses		
Select three or more of the following:		9
ME 607	Advanced Thermodynamics	
ME 618	Selected Topics in Mechanical Engineering	
ME 621	Advanced Mechanics of Material	
ME 622	Finite Element Methods in Mechanical Engineering	
ME 624	Microlevel Modeling in Particle Technology	
ME 625	Introduction to Robotics	
ME 630	Analytical Methods in Machine Design	
ME 636	Mechanism Design: Analysis and Synthesis	
ME 637	Kinematics of Spatial Mechanisms	
ME 655	Introduction to Modern Control Methods	
ME 670	Introduction to Biomechanical Engineering	
ME 678	Engineering Design of Plastic Products	
ME 679	Polymer Processing Techniques	
ME 712	Mechanics of Viscous Fluids	
ME 713	Non-Newtonian Fluid Dynamics	
ME 714	Principles of Particulate Multiphase Flows	
ME 717	Selected Topics in Mechanical Engineering I	
ME 718	ST: (Selected Topics in Mechanical Engineering II)	

ME 735	Advanced Topics in Robotics	
ME 736	Advanced Mechanism Design	
ME 738	Computer Aided Engineering	
General Elective Courses		
Graduate courses from other departments or programs		9
Seminar		
ME 794	Mechanical Engineering Colloquium [1]	0
Total Credits		30

[1] Required for two semesters.

M.S. in Mechanical Engineering (Master's project)

Code	Title	Credits
Required Courses		
ME 616	Matrix Methods in Mechanical Engineering	3
or MATH 651	Methods of Applied Mathematics I	
Select three of the following:		9
ME 610	Applied Heat Transfer	
ME 611	Dynamics of Incompressible Fluids	
ME 614	Continuum Mechanics	
ME 620	Mechanics of Materials	
ME 632	Mechanical Engineering Measurements	
ME 635	Computer-Aided Design	
Project		
ME 700B	Master's Project	3
Elective ME Graduate Courses		
Select two or more of the following:		6
ME 607	Advanced Thermodynamics	
ME 618	Selected Topics in Mechanical Engineering	
ME 621	Advanced Mechanics of Material	
ME 622	Finite Element Methods in Mechanical Engineering	
ME 624	Microlevel Modeling in Particle Technology	
ME 625	Introduction to Robotics	
ME 630	Analytical Methods in Machine Design	
ME 636	Mechanism Design: Analysis and Synthesis	
ME 637	Kinematics of Spatial Mechanisms	
ME 655	Introduction to Modern Control Methods	
ME 670	Introduction to Biomechanical Engineering	
ME 678	Engineering Design of Plastic Products	
ME 679	Polymer Processing Techniques	
ME 712	Mechanics of Viscous Fluids	
ME 713	Non-Newtonian Fluid Dynamics	
ME 714	Principles of Particulate Multiphase Flows	
ME 717	Selected Topics in Mechanical Engineering I	
ME 718	ST: (Selected Topics in Mechanical Engineering II)	
ME 735	Advanced Topics in Robotics	
ME 736	Advanced Mechanism Design	
ME 738	Computer Aided Engineering	
General Elective Courses		
Graduate courses from other departments or programs		9
Seminar		

ME 794	Mechanical Engineering Colloquium [1]	0
Total Credits		30

[1] Required for two semesters.

M.S. in Mechanical Engineering (Master's thesis)

Code	Title	Credits
Required Courses		
ME 616	Matrix Methods in Mechanical Engineering	3
or MATH 651	Methods of Applied Mathematics I	
Select three of the following:		9
ME 610	Applied Heat Transfer	
ME 611	Dynamics of Incompressible Fluids	
ME 614	Continuum Mechanics	
ME 620	Mechanics of Materials	
ME 632	Mechanical Engineering Measurements	
ME 635	Computer-Aided Design	
Thesis [1]		
ME 701B & 701B	Master's Thesis and Master's Thesis	6
or ME 701C	Master's Thesis	
Elective ME Graduate Courses		
Select one or more of the following:		3
ME 607	Advanced Thermodynamics	
ME 618	Selected Topics in Mechanical Engineering	
ME 621	Advanced Mechanics of Material	
ME 622	Finite Element Methods in Mechanical Engineering	
ME 624	Microlevel Modeling in Particle Technology	
ME 625	Introduction to Robotics	
ME 630	Analytical Methods in Machine Design	
ME 636	Mechanism Design: Analysis and Synthesis	
ME 637	Kinematics of Spatial Mechanisms	
ME 655	Introduction to Modern Control Methods	
ME 670	Introduction to Biomechanical Engineering	
ME 678	Engineering Design of Plastic Products	
ME 679	Polymer Processing Techniques	
ME 712	Mechanics of Viscous Fluids	
ME 713	Non-Newtonian Fluid Dynamics	
ME 714	Principles of Particulate Multiphase Flows	
ME 717	Selected Topics in Mechanical Engineering I	
ME 718	ST: (Selected Topics in Mechanical Engineering II)	
ME 735	Advanced Topics in Robotics	
ME 736	Advanced Mechanism Design	
ME 738	Computer Aided Engineering	
General Elective Courses		
Graduate courses from other departments or programs		9
Seminar		
ME 794	Mechanical Engineering Colloquium [2]	0
Total Credits		30

[1] Required of all students who receive departmental or research-based awards.

[2] Required every semester.

M.S. in Occupational Safety and Health Engineering

Degree Requirements

A minimum of 36 credits is required.

Students who lack an appropriate background may be admitted and required to make up deficiencies by taking a program of bridge courses that is designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Seminar: In addition to the minimum 36 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

M.S. in Occupational Safety and Health (courses only)

Code	Title	Credits
Required Courses		
EM 633	Legal Aspects of Health and Safety	3
IE 604	Advanced Engineering Statistics	3
IE 614	Safety Engineering Methods	3
IE 615	Industrial Hygiene and Occupational Health	3
IE 665	Applied Industrial Ergonomics	3
IE 685	Systems Safety	3
Elective Courses		
Select six of the following:		18
BME 670	Introduction to Biomechanical Engineering	
BME 671	Biomechanics of Human Structure and Motion	
EVSC 603	Hazardous Waste Operations and Emergency Response	
EVSC 614	Quantitative Environmental Risk Assessment	
EVSC 616	Toxicology	
IE 608	Product Liability Control	
IE 661	Man-Machine Systems	
IE 662	Cognitive Engineering	
IE 664	Advanced Ergonomics	
IE 669	Human Design Factors in Engineering	
IE 675	Safety in Facility and Product Design	
IE 681	Interdisciplinary Seminar in Occupational Safety and Health	
IE 682	Industrial Safety and Health Evaluation	
IE 700	Master'S Project	
IE 725	Independent Research	
ME 660	Noise Control	
Total Credits		36

M.S. in Occupational Safety and Health (Master's thesis)

Code	Title	Credits
Required Courses		
EM 633	Legal Aspects of Health and Safety	3
IE 604	Advanced Engineering Statistics	3
IE 614	Safety Engineering Methods	3
IE 615	Industrial Hygiene and Occupational Health	3
IE 665	Applied Industrial Ergonomics	3
IE 685	Systems Safety	3
Thesis [1]		
IE 701		6
Elective Courses		

Select four of the following:		12
BME 670	Introduction to Biomechanical Engineering	
BME 671	Biomechanics of Human Structure and Motion	
EVSC 603	Hazardous Waste Operations and Emergency Response	
EVSC 614	Quantitative Environmental Risk Assessment	
EVSC 616	Toxicology	
IE 608	Product Liability Control	
IE 661	Man-Machine Systems	
IE 662	Cognitive Engineering	
IE 664	Advanced Ergonomics	
IE 669	Human Design Factors in Engineering	
IE 675	Safety in Facility and Product Design	
IE 681	Interdisciplinary Seminar in Occupational Safety and Health	
IE 682	Industrial Safety and Health Evaluation	
IE 700	Master'S Project	
IE 725	Independent Research	
ME 660	Noise Control	
Total Credits		36

[1] Required for NIOSH; trainees; optional for all others.

M.S. in Pharmaceutical Systems Management

Degree Requirements

A minimum of 30 credits beyond a B.S. degree is required. A thesis or independent research is optional.

M.S. in Pharmaceutical Systems Management (courses only)

Code	Title	Credits
Core Courses		
EM 602	Management Science	3
EM 636	Project Management	3
IE 673	Total Quality Management	3
IE 618	Engineering Cost and Production Economics	3
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
Elective Courses		
Select four of the following:		12
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 635	Management of Engineering Research and Development	
IE 699	Special Topics in Industrial Engineering	
EM 637	Project Control	
IE 659	Supply Chain Engineering	
IE 621	Systems Analysis and Simulation	
MNE 601	Computerized Manufacturing Systems	
PHEN 605	Pharmaceutical Packaging Technology	
PHEN 602	Pharmaceutical Facility Design	
HRM 601	Organizational Behavior	
Total Credits		30

M.S. in Pharmaceutical Systems Management (independent research)

Code	Title	Credits
Core Courses		
EM 602	Management Science	3
EM 636	Project Management	3
IE 673	Total Quality Management	3
IE 618	Engineering Cost and Production Economics	3
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
Independent Research		
PHEN 725	Independent Study	3
Elective Courses		
Select three of the following:		9
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 635	Management of Engineering Research and Development	
IE 699	Special Topics in Industrial Engineering	
EM 637	Project Control	
IE 659	Supply Chain Engineering	
IE 621	Systems Analysis and Simulation	
MNE 601	Computerized Manufacturing Systems	
PHEN 605	Pharmaceutical Packaging Technology	
PHEN 602	Pharmaceutical Facility Design	
HRM 601	Organizational Behavior	
Total Credits		30

M.S. in Pharmaceutical Systems Management (Master's thesis)

Code	Title	Credits
Core Courses		
EM 602	Management Science	3
EM 636	Project Management	3
IE 673	Total Quality Management	3
IE 618	Engineering Cost and Production Economics	3
PHEN 601	Principles of Pharmaceutical Engineering	3
PHEN 604	Validation and Regulatory Issues in the Pharmaceutical Industry	3
Thesis		
PHEN 701B & 701B	Master'S Thesis and Master'S Thesis	6
or PHEN 701C	Master'S Thesis	
Select two of the following:		6
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	
EM 635	Management of Engineering Research and Development	
IE 699	Special Topics in Industrial Engineering	
EM 637	Project Control	
IE 659	Supply Chain Engineering	
IE 621	Systems Analysis and Simulation	
MNE 601	Computerized Manufacturing Systems	
PHEN 605	Pharmaceutical Packaging Technology	
PHEN 602	Pharmaceutical Facility Design	
HRM 601	Organizational Behavior	
Total Credits		30

Ph.D. in Industrial Engineering

The curriculum for this major is currently under review and will be updated shortly. In the meantime please contact with your advisor.

Ph.D. in Mechanical Engineering

The program is for superior students with master's degrees in mechanical engineering, or closely related fields, who wish to do advanced research in an area of mechanical engineering. It provides students with
the skills necessary for careers in basic and applied research, as well as the intellectual foundation to provide leadership in academia and industry.
In exceptional circumstances, highly qualified students with bachelor's degrees in mechanical engineering may be accepted directly into the doctoral program.

Degree Requirements

Coursework registration requirements: Ph.D. students with a recognized Master's degree or equivalent are required to take four 700#level 3#credit courses (12 credits). Ph.D. students with a recognized Baccalaureate degree are required to take eight 600#level or 700#level 3#credit courses (24 credits) of
coursework beyond the Baccalaureate degree as well as four additional 700#level 3#credit courses (12 credits), for a total of twelve 3#credit courses (36 credits). Master's project (course 700), Master's thesis
(course 701), or more than two independent study courses (courses 725 and 726) cannot be used to satisfy these coursework requirements. A Ph.D. student may substitute a 600#level course for a 700#level
course only after the academic advisor appeals on behalf of the student to the Office of Graduate Studies and receives approval. The program or the student's dissertation committee may ask the student to take additional courses above the aforementioned minimum requirements.

Dissertation registration requirements: Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre#doctoral research (792B) per semester until they defend successfully
the dissertation proposal. Specific dissertation topics are approved by the department on an individual basis. Ph.D. students who defend the dissertation proposal successfully must then register for the 1#credit dissertation course (790A) each semester until they complete all degree requirements. Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.

Program deadlines for full#time students: The required coursework for the Ph.D. program and the (major part of the) QE must be completed successfully by the end of the second year in the program. The dissertation proposal must be defended successfully either by the end of the third year in the Ph.D. program or four semesters after registering for the first time in the 792 pre#doctoral research course, whichever occurs earlier. The dissertation must be defended successfully by the end of the sixth year in the Ph.D. program.

Qualifying Examination

Before becoming a doctoral candidate, a student must demonstrate his/her ability to integrate the knowledge acquired studies in the Qualifying Examination. The examination will evaluate the students' knowledge in selected areas of mechanical engineering, as well his/her research potential which will be
based on the student's formal research prospectus submitted in written form. After receiving the research prospectus, the department will form a committee of 3 or more members to conduct an oral examination.

The formal research prospectus should contain the following information:

- Abstract: A summary of the research reported in the prospectus
- Background and Significance: (a) Demonstrate knowledge of breadth of literature underlying the reported research; (b) Identify the unsolved problems and their significance; and (c) Show the planned approach to address the problems.
- Research Work and Preliminary Results: (a) Show the theoretical development and/or the experimental design of the approach used in the research; and (b) Show the results obtained.
- Discussions and Conclusions: Discussion of the results, which may include a comparison with the expected results, if applicable, and potential problems.
- Future Work: Identify the problems that needs to be addressed if the reported research is to be continued.
- References: List of the publications cited in the background literature survey and other related reference materials.

The maximum length of formal research prospectus is 15 pages single#spaced, excluding references. Additional pages may be used as appendix only if necessary.

Dissertation Proposal Examination

After passing the qualifying examination, Doctoral students, under the guidance of their faculty advisors, must conduct preliminary research in a specific topic and prepare a written research proposal. The dissertation topic should represent original research and reflect a student's ability to critically understand the significance of a problem. The proposal must provide approaches for developing potential solutions to the problem. Doctoral students must make an oral presentation of the dissertation topic for approval by their dissertation committees. The dissertation proposal should follow the format required for the final dissertation document.

Dissertation Defense

When the novel and independent dissertation research conducted by a doctoral student produces sufficient and significant results, the student, in consultation with his/her dissertation committee, will prepare for the completion of the dissertation. An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Project Management

NJIT recognizes the industry need for highly skilled individuals to plan project implementation and control progress, along with the ability to estimate, budget, and control capital investments. Project Management courses are taught by instructors with experience in the field and PMP certification. Many students find that this program enhances their work performance and marketability.

Who is suited for this program?

This certificate program is intended for individuals seeking to enhance their project management skills and relates to Engineering Management.

What are the Required Courses?

Code	Title	Credits
Core Courses		
EM 637	Project Control	3
EM 691	Cost Estimating for Capital Projects	3
Electives		
Select one of the following:		3
EM 636	Project Management	
CE 610	Construction Management	
Select one of the following:		3
EM 631	Legal Aspects in Environmental Engineering	
EM 632	Legal Aspects in Construction	
EM 633	Legal Aspects of Health and Safety	
EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers	

What will I learn?

- Project Control focuses on the methodology that can be employed to plan project implementation and control progress.
- Cost Estimating for Capital Projects examines internal and external influences on the economic practices of business; classical and current theories of economic behavior; contemporary analytical techniques; behavior of costs, prices, and profits; demand analysis, competition and monopoly; capital expenditure planning; profit theories and business cycles; and econometric models of market strategies, competitive action, and demand behavior.
- Project Management focuses on technical-oriented projects, however the principles discussed are applicable to the management of any project. Topics include time, cost considerations, cash flow forecasting, financial and performance control, documentation.
- Construction Management is comprised of a study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning.
- Legal Aspects in Environmental Engineering discusses the control of air, water, and solid waste pollution by federal, state, and local government statutes and international law.
- Legal Aspects in Construction is an introduction to the legal factors affecting construction activities: contract responsibilities of contractors, engineers, and owners; subcontracts and third-party liability; construction law and code compliance; and insurance and bonds.
- Legal, Ethical and Intellectual Property Issues for Engineering Managers is an introduction to various environmental, product liability, health and safety, and intellectual property, legal, as well as ethical, issues facing engineering managers. Current New Jersey and federal laws and pending legal actions in these fields.

For more information about the online graduate certificate in Construction Management click here (http://engineeringmasters.njit.edu/lpkp-certpm/?utm_source=NJIT&utm_medium=website&utm_campaign=S_SearchEngine2&src=S_SearchEngine2) AND For more information about the online graduate certificate in Project Management click here (http://engineeringmasters.njit.edu/lpkp-certpm/?utm_source=NJIT&utm_medium=website&utm_campaign=S_SearchEngine2&src=S_SearchEngine2)

Why study Project Management at NJIT?

Project Management can be studied fully online or on our NJIT Newark campus. You'll have access to the same outstanding facilities and professors as full-time NJIT students, plus the flexibility you need to juggle all the aspects of your life.

Prerequisites

Eligibility for admission requires completion of an undergraduate degree in engineering, the sciences or a closely related area.

Related Degree Programs

All credits for Project Management relates in its entirety to NJIT MS in Engineering Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/project-management-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Athanassios Bladikas (http://directory.njit.edu/PersDetails.aspx?persid=bladikas)

Supply Chain Engineering

The fundamental knowledge of the industrial engineering and engineering management profession encourages a systems viewpoint that permits us to reduce costs while at the same time maintain or further increase operational performance. The confluence of information technology and systems engineering has made the roles of industrial engineering and engineering management relevant in a wide range of industries. The supply chain contributes a very substantial portion to total product cost. Managing it requires the optimization of the entire system and its various components, that include among others, transportation, inventory, warehousing, materials handling, and customer service.

The graduate certificate in Supply Chain Engineering program at NJIT is designed to distribute this type of knowledge.

What are the Required Courses?

Code	Title	Credits
Core Courses		
IE 659	Supply Chain Engineering	3
EM 640	Distribution Logistics	3
Electives		
Select two of the following:		6
EM 602	Management Science	3
EM 636	Project Management	3
IE 604	Advanced Engineering Statistics	3
IE 618	Engineering Cost and Production Economics	3

What will I learn?

- *Supply Chain Engineering* - Coordination of product manufacturing and logistic activities across the global supply chain is studied. Focus is on supply chain design, implementation, and control. Topics include transportation and distribution networks, inventory control, demand planning, materials handling and warehousing, supply chain contracts, manufacturing flexibility, product design for responsiveness, and ERP systems. Supply chain analytics concepts and relevant case studies are introduced.
- *Distribution Logistics* - Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin.
- *Management Science* - Linear programming: formulation, methodology, and application; the transportation problem; the assignment problem; Markov chains and their applications in decision making; queueing systems; deterministic and stochastic inventory models.
- *Project Management* - Introduction to concepts of project management and techniques for planning and controlling of resources to accomplish specific project goals. While the focus is on technically oriented projects, the principles discussed are applicable to the management of any project. Topics include time, cost considerations, cash flow forecasting, financial and performance control, documentation.
- *Advanced Engineering Statistics* - The foundations of modern quality improvement, scientific basis of quality engineering, probability, statistical inference, statistical experimental design issues such as randomized blocks, factorial design at different levels, application to factorial design, building models, and implementation and critique of Taguchi's contributions. Statistical software is used in the data analysis.
- *Engineering Cost and Production Economics* - Cost management of operational activities. Focuses on capital investment decision making and efficient resource utilization to achieve cost-effective operations. Topics include alternative investment evaluation, budgeting activity based costing,

quality costs, life cycle management and relevant behavioral science. These are considered in the context of manufacturing and service industry application

Why study Supply Chain Engineering at NJIT?

The NJIT supply chain initiative will help enable you to build flexible manufacturing solutions for use within small to medium-sized companies. You will help develop a methodology for evaluating the quality manufacturability of new designs from an assembly perspective. This program is related to all manufacturing industries and all transportation/distribution related service industries. Potential job titles include:

- Supply Chain Engineer
- Logistics Planner
- Transportation Analyst
- Terminal Manager
- Purchasing Agent
- Dispatch Coordinator
- Customer Service Agent
- Distribution Analyst
- Warehouse Supervisor

Prerequisites

Students who do not have a bachelor of science degree in industrial engineering may be admitted and required to complete the bridge program, especially in the areas of statistics, cost analysis and engineering economics. Bridge courses do not count toward degree requirements. A minimum of 30 credits beyond a baccalaureate degree is required.

Related Degree Programs

The graduate certificate in Supply Chain Engineering relates directly to the NJIT MS in Industrial Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/industrial-ms/), MS in Engineering Management (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/engineering-management-ms/), and MS in Manufacturing Systems Engineering (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/mechanical-industrial/manufacturing-systems-ms/)

Faculty Advisor: Dr. Sanchoy K. Das (http://mie.njit.edu/people/das.php)

Interdisciplinary Program in Engineering Science

The M.S. in Engineering Science allows students to study areas not covered by traditional engineering or science discipline graduate programs. For those already in the work force, the program provides the opportunity to develop expertise relevant to their work

Master of Science in Engineering Science

This is a very flexible program that permits advanced study from numerous disciplines in engineering and the sciences.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in science or engineering. Candidates with other appropriate backgrounds may be considered.

- Engineering Science - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/newark-college-engineering/interdisciplinary-engineering-science/ms/)

Interdisciplinary Program in Engineering Science Courses

ESC 701B. Master'S Thesis. 3 credits, 3 contact hours.

M.S. in Engineering Science

Degree Requirements

To ensure academic success in their graduate studies, students may be required to take additional undergraduate or graduate courses before beginning graduate curricula. This program of bridge courses will be individually-designed in consultation with the student’s graduate advisor. Such courses are not counted toward degree requirements.

A minimum of 30 credits is required. A thesis or project may be included.

Seminar: In addition to the minimum 30 degree credits, all students who receive departmental or research-based awards must enroll each semester in a graduate seminar. The seminar is selected in consultation with the graduate advisor.

M.S. in Engineering Science (courses only)

Code	Title	Credits
Required		
MATH 6XX	Two 600-level math courses	6
One 600-level physics, chemistry, or biology course		3
Two 600-level engineering courses		6
Electives [1]		
Select five courses in consultation with graduate advisor		15
Total Credits		30

1 The elective credits must form a meaningful and coherent program integrated with the specialization in science or engineering.

M.S. in Engineering Science (Master's project)

Code	Title	Credits
Required		
MATH 6XX	Two 600-level math courses	6
One 600-level physics, chemistry, or biology course		3
Two 600-level engineering courses		6
Project		
Master's project		3
Electives [1]		
Select four courses in consultation with graduate advisor		12
Total Credits		30

1 The elective credits must form a meaningful and coherent program integrated with the specialization in science or engineering.

M.S. in Engineering Science (Master's thesis)

Code	Title	Credits
Required		
MATH 6XX	Two 600-level math courses	6
One 600-level physics, chemistry, or biology course		3
Two 600-level engineering courses		6
Thesis		
Master's thesis		6
Electives [1]		
Select three courses in consultation with graduate adviso		9
Total Credits		30

1 The elective credits must form a meaningful and coherent program integrated with the specialization in science or engineering.

Martin Tuchman School of Management

The Martin Tuchman School of Management (MTSM) is one of NJIT's six schools and colleges, serving as the university's business school. MTSM has 33 faculty and approximately 700 students. The mission of the Tuchman School is educate and prepare our graduates for life-long success as management professionals, corporate leaders and academic scholars in the dynamic, technology-driven world of global business.

Embedded within New Jersey’s technological university, the Tuchman School integrates fundamental business principles with technical knowledge and critical-thinking skills and leverages strengths across the university from engineering and computing to architecture and social science. Many of our graduate programs are STEM-designated; and all of our academic programs provide hands-on learning experiences with advanced business and management cloud-based solutions.

NJIT's Martin Tuchman School of Management is one of 799 business schools across 53 countries to be accredited by AACSB, The Association to Advance Collegiate Schools of Business. AACSB accreditation represents the highest standard of achievement for business schools worldwide. All of our undergraduate business specializations and our graduate Management of Science and MBA programs are accredited.

Programs

- Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/)
- Management of Technology - M.B.A. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/)

Executive Program (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/executive-program/)

- Management of Technology - E.M.B.A. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-emba/)

Business Data Science - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/business-data-science-phd/)

Programs

- Finance for Managers (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/finance-for-managers-cert/)
- Financial Technology (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/financial-technology-cert/)
- Management Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/management-essentials-cert/)
- Management for Technology (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/management-of-technology-cert/)

ACCT 615. Management Accounting. 3 credits, 3 contact hours.
Builds on traditional concepts of managerial accounting (break-even analysis, alternate choice decisions, profit planning, and transfer pricing) and develops the skills that an executive needs in strategic cost analysis. Explores strategic decisions of value chains and activity-based management. Emphasis on using managerial accounting data in executive planning and control.

BDS 725. Independent Research I. 3 credits, 3 contact hours.
Restriction: graduate standing and school consent.

BDS 726. Independent Study II. 3 credits, 3 contact hours.
Restriction: graduate standing and school consent.

BDS 790A. Doctoral Dissertation & Res. 1 credit, 1 contact hour.
Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (790A) each semester until they complete all degree requirements.Research and writing in the area of business data science are carried out under the supervision of a designated graduate faculty member. The completed written dissertation should be a substantial contribution to the knowledge of the topic under research, and should be of sufficient merit to warrant publication in a leading scientific or technical journal.

BDS 791. Doctoral Seminar. 0 credits, 0 contact hours.

BDS 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Ph.D. students who pass the Qualifying Examination (QE) must then register for 3 credits of pre-doctoral research (792B) per semester until they defend successfully the dissertation proposal. Research and writing in the area of business data science are carried out under the supervision of a designated graduate faculty member for prepration of a dissertation proposal.

ECON 610. Managerial Economics. 3 credits, 3 contact hours.
Managerial Economics covers the role of economic theory in management analysis and decisions. The study of demand, cost, and supply theories from a business viewpoint are also covered. This course is about economic principles and their relevance to business decision-making. The course examines the interaction of information, economic incentives and market competition and how these interact to determine prices, products available, profits, and patterns of trade and organization.

ENTR 725. Independent Study. 3 credits, 3 contact hours.

FIN 516. Principles of Financial Management. 3 credits, 3 contact hours.
Fundamentals of financial management divided into two segments: investment and corporation finance.

FIN 600. Corporate Finance I. 3 credits, 3 contact hours.
This course introduces concepts and analytical tools to identify and solve Financial Management problems. After introducing the corporation, the course focuses on how firms invest in real assets (capital budgeting) and how they raise money to pay for assets (financing). Practical problems in valuing bonds, stocks and other investments will be based on the time value of money. The trade-off between risk and return will be introduced with the Capital Asset Pricing Model.

FIN 610. Global Macro Economics. 3 credits, 3 contact hours.
FIN 610 is an introductory graduate course for entering master's students that will also be taking other core Master's courses such as accounting. The course introduces various concepts relating to macroenomics and the financial environment from both a theoretical and institutional perspective. Thus fiscal and monetary policy and actions are covered but are taught using a macroeconomic model that helps identify how particular actions affect the money and goods economies as well as specific financial institutions.

FIN 611. Intro to Topics in Fin Tech. 3 credits, 3 contact hours.
Prerequisites: Students must have taken an introductory programming course prior to enrolling in FIN 611 that concentrated on learning at least one of Python, Java, MATLAB, C/C++, or R. The financial services industry is presently undergoing dramatic changes as recent technological advances have enabled the automation of former workflows. This course will survey current trends in the Financial Technology (FinTech) industry. Students will have the opportunity to develop their own software related to FinTech ideas discussed during this course.

FIN 616. Data Driven Financial Modeling. 3 credits, 3 contact hours.
Prerequisite: FIN 600. Financial modeling driven by financial data is of critical importance to asset allocation, pricing, trading strategies, and risk management. By introducing basic and current financial modeling techniques, this course equips students with new analytic and modeling tools (e.g., spreadsheet modeling) to tackle rapidly changing and dynamic financial markets. In particular, this course delivers modeling frameworks such as regression analysis, forecasting, Monte-Carlo simulation and optimization; and it illustrates how to apply these frameworks in financial contexts such as portfolio management, term-structure estimation, capital budgeting, risk measurement, risk analysis in discounted cash flow models, and pricing of European, American, exotic, and real options.

FIN 618. Public and Private Financing of Urban Areas. 3 credits, 3 contact hours.
Ties government's budget, tax policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. Same as MIP 618 and Tran 604.

FIN 620. Adv Financial Data Analytics. 3 credits, 3 contact hours.
Prerequisites: FIN 616 or instructor's approval, and familiarity with at least one programming language (for example, C, Java, Python, R or MATLAB). Data-driven finance becomes the mainstream from Wall Street to Main Street. Large financial institutions (for example, Bank of America Merrill Lynch with its Quartz project or JP Morgan Chase with the Athena project) strategically use Python with other established technologies to build, enhance, and maintain some of their core IT systems. There is also a multitude of larger and smaller hedge funds that make heavy use of Python programming when it comes to efficient financial application development and productive data analytics efforts. Establishing quantitative view and mastering analytical approaches are critical nowadays for students and professionals in the finance industry. It becomes a necessary skill set for personal investors. This course will provide essential skills in finance data analytics and vital capacity to quickly create, develop, and deploy trading models.

FIN 624. Corporate Finance II. 3 credits, 3 contact hours.
Prerequisite:FIN 600. The trade-off between risk and return will be examined in the context of historical analysis, portfolio optimization, the Capital Asset Pricing Model and other alternative models. The course will begin with the understanding of the Modigliani and Miller results and introduce bankruptcy, taxes, information asymmetries and other market imperfections. Financial options, put-call parity and option pricing will be introduces.

FIN 626. Financial Investment Institutions. 3 credits, 3 contact hours.
Prerequisite: FIN 600. Introduces the role of banking institutions and investment banks in the domestic and international money market and capital environment to the financial managers. Covers instruments and services of financial intermediaries that are crucial to business management. Discussions range from the financial services and facilities of regional banks to money-center banking institutions. Alternatives of project financing, lending requirements and regulations, project financing, and role of intermediaries in local and international transactions. Focuses on the private placement procedures of all types of securities in the capital market and the unique role undertaken by the investment banking firms. Provides an insight about the public offering process for existing and venture capitalized firms.

FIN 627. International Finance. 3 credits, 3 contact hours.
Prerequisite: FIN 600. Examines financing of exports and imports, managing multicurrency working capital, international aspects of capital budgeting, cost of capital and their relationship with political, economic, and financial risk. Explores financial innovations and their impact on the firm's financial strategy and performance of overall productivity. Discusses the tax consequences and principal-subsidiary relationship of the multinational enterprise. Introduces international money and capital markets, instruments, derivatives, and institutions.

FIN 634. Mergers, Acquisitions, and Restructuring. 3 credits, 3 contact hours.
Prerequisite: FIN 600. Focuses on identifying and evaluating potential and international companies for mergers and acquisitions as well as structuring of deals. The financial, social and managerial implications of these changes in corporate ownership will be examined. Topics are: financing M&As, deal structuring, tax implications, valuation, broker/finder agreements, merger negotiations, and post-merger integration.

FIN 641. Derivatives Markets. 3 credits, 3 contact hours.
Prerequisite: FIN 600. This course introduces students to futures, options, and other derivative securities. Topics include option valuation models, principles of forward and futures pricing, structure of markets for derivative securities, and strategies for hedging and speculation.

FIN 642. Derivatives and Structured Finance. 3 credits, 3 contact hours.
Prerequisites: FIN 641. This is a second course in the instruments created by modern financial engineering. It continues the study of derivatives from FIN 641 (Derivatives Markets), covering additional types of options and of underlying assets. The second part of the course is devoted to structured finance, including securities backed by mortgages and other types of assets.

FIN 643. Term Structure of Interest Rates. 3 credits, 3 contact hours.
Prerequisites: FIN 642 (Derivatives and Structure Finance), MATH 605 (Stochastic Calculus). This course provides the student with a basic understanding of models of the term-structure of interest rates and the pricing of derivatives on bonds and other interest-rate-based securities. Topics covered include arbitrage-free pricing principles, continuous-time interest-rate models, no-arbitrage term structure models, multifactor models, forward measure approach, market models and model calibration.

FIN 644. Credit Risk Modeling. 3 credits, 3 contact hours.
Prerequisites: FIN 643 (Term Structure of Interest Rates), MATH 605 (Stochastic Calculus). This course covers types of credit risk, measurement of credit risk, and methods for changing exposure to credit risk using credit derivatives. Current models for pricing credit derivatives will be analyzed and applied.

FIN 650. Investment Analysis and Portfolio Theory. 3 credits, 3 contact hours.
Prerequisite: FIN 600. This is a basic course in the theory and practice of investing. We will study in depth why and how to form portfolios of securities. A significant amount of mathematical and statistical analysis will be used in answering these questions. Theories of asset pricing based on the relationship between risk and return will be included. We will also discuss criteria for selecting specific securities in different asset classes, such as, stocks, bonds, and derivatives.

FIN 655. Financial Innovations and Market Failures. 3 credits, 3 contact hours.
Prerequisite: FIN 600. This reading intensive course introduces concepts and problems from derivative markets, entrepreneurial finance, and financial market failures (including financial bubbles). The course focuses on valuation of futures and options (including real options), strategy and incentives for new finance, and information asymmetry and market failures, especially financial market bubbles.

FIN 700. Seminar in Theory and Research in Financial Management. 3 credits, 3 contact hours.
Prerequisites: FIN 624 or FIN 626. Only open to those students who do not do a thesis. The theory and applied tools of financial management. Presented in seminar format with several students working as a team to analyze and resolve an issue in financial management.

FIN 701. Thesis in Financial Management. 3 credits, 3 contact hours.
Prerequisites: FIN 624 or FIN 626; waived with approval of the assistant dean for graduate programs. Examines:What is research? Why do research? What are the objectives of research? Covers the need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

FIN 725. Independent Study. 3 credits, 3 contact hours.

HRM 601. Organizational Behavior. 3 credits, 3 contact hours.
Analysis of key organizational components; individual perception; learning ability; conflict resolution models; group processes in decision making; motivation; problem diagnosis, and the organization as the mechanism for joining into a coherent productive system. Organizational assessment for innovation, leadership styles, and environmental interaction.

HRM 606. Human Resource Management. 3 credits, 3 contact hours.
Management of human resources in business, industry, and government; developing personnel programs including wage and job classification, training, employee and labor relations, and accident prevention. Particular attention is directed to cases and roles involving both line and staff managers.

HRM 610. Seminar on Leadership Skills. 3 credits, 3 contact hours.
Leadership theory and research is used to provide a foundation for developing leadership skills in work organizations. This course covers all aspects of leadership properties and processes. Concepts and theory are reinforced with case studies and experiential learning exercises. Topics include charismatic leadership, forming and realizing a vision, motivating and socializing followers, conflict resolution, negotiation, power and authority, and values and ethics.

HRM 630. Managing Technological and Organizational Change. 3 credits, 3 contact hours.
Managing planned and unplanned change in organizations. The change process is studied in relation to technology-driven changes in the workplace and to other environmental factors. Focuses on planned and unplanned systemic change, such as downsizing, re-engineering, mergers, and acquisitions.

HRM 640. Cultures in Organization. 3 credits, 3 contact hours.
Prerequisite: HRM 601. Cultures and subcultures in organizations are studied from an ethnographic perspective. Managerial and professional cultures are studied as are engineering and R&D cultures. Organizational cultures are also studied in detail using case studies, with an emphasis on understanding culture as a control mechanism in modern organizations.

HRM 685. Cross Cultural Management Studies. 3 credits, 3 contact hours.
Provides insight into the institutional fabric and social and communication behavior of other cultures to better understand problems arising from cultural aspects of managing and doing business in various countries. Focus will be with the manager acting in various cultural environments, not restricted to the traditional human resource function at corporate headquarters. Cultural differences and technologies are also examined.

MGMT 501. Management Foundations. 3 credits, 3 contact hours.
This course provides foundation knowledge for MSM and MBA students whose undergraduate coursework does not include coursework in accounting and finance. It therefore, serves as a pre-qualifier for the MSM and MBA programs.

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Technology as a main component of an organizational entity. Generation, development, and implementation of technology are outlined. Influence of technology on global competitiveness is also discussed.

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Distribution logistics emphasizing techniques used to optimize corporate profit and customer service; transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. Same as EM 640 and TRAN 640.

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Prerequisite: FIN 516. For the student who is considering starting or managing a new business. The course combines classroom instruction in business management and a term project involving the analysis of a business case. The course is designed to build upon and integrate the student's previously acquired business knowledge and skills into an understanding of how to start and run a new business.

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MGMT 660. Managing Supply and Value Chains. 3 credits, 3 contact hours.
This course is focused on the flow of products, information and revenue across supply and value chains in organizations. Special emphasis is placed on emerging e-business models and their effects on supply and value chains, and customer relationship management. The course also includes a survey of relevant information technologies.

MGMT 670. International Business. 3 credits, 3 contact hours.
Covers the scope and the essential characteristics of international business in the world economy; MNEs as economic, political, and social institutions; national and international control; functional management and operations; country evaluation; and regional market analysis.

MGMT 680. Entrepreneurial Strategy. 3 credits, 3 contact hours.
For the student who is considering starting and/or managing a new business. Integrates knowledge of the different aspects of business that have been learned as separate subjects. Provides an understanding of the decisions that guide the overall operations of an entrepreneurial business organization and how it interacts with its markets, competitors, and suppliers. Combines classroom instruction in business strategy along with case analysis of small firms. Should be taken in the last semester of the program, unless prior arrangement has been made with the instructor or the graduate advisor. Taken in the final semester only.

MGMT 682. Business Research Methods I. 3 credits, 3 contact hours.
A comprehensive introduction to business research methods covering the fundamental concepts of problem definition and the research process including quantitative and qualitative research, survey research, observation methods and experimental research methods. The course also covers data analytics, including advanced descriptive and predictive analysis models, involving inferential statistics, regression and correlation analyses and non-parametric methods. The course emphasizes problem solving using advanced quantitative software tools such as SPSS, Munitab, SAS, MathLab, and R. Students will be required to work on business research case studies and projects involving the collection and/or treatment of large data sets, as well as to develop research constructs and hypotheses and to write and present reports documenting research findings and recommendations.

MGMT 685. Operations Research and Decision Making. 3 credits, 3 contact hours.
Introduces the concepts of objective functions and constraints, concepts of value and utilities, optimization algorithms, networks, and game theory. Covers models of linear programming, inventory systems, multi-criteria decision-making, project management, and transportation planning. Topics discussed from probabilistic and deterministic approaches.

MGMT 686. Corporate Governance. 3 credits, 3 contact hours.
Presents inter-disciplinary perspectives on the rights, responsibilities and roles of the corporation in society. Focuses on the relationships among owners, managers, and other stakeholders. Analyzes corporate control mechanisms including ownership concentration, executive compensation, boards of directors, and the market for corporate control. Includes changes in political/legal/regulatory institutional environments over time, and develops a comparative international framework.

MGMT 688. Information Technology, Business and the Law. 3 credits, 3 contact hours.
Includes historical and constitutional foundations, crimes, and torts in cyberspace, virtual property (patents online, copyrights in digital information, trade secrets in cyberspace, and cybermarks), electronic commerce contracting, electronic commerce, electronic money and the law, and information technology and online infringement of rights of intellectual property.

MGMT 691. Legal and Ethical Issues. 3 credits, 3 contact hours.
Explores the legal and ethical responsibilities of managers. Analyzes extent to which shareholders should be allowed to exercise their legitimate economic, legal, and ethical claims on corporate managers; extent of regulation of a particular industry, individual rights of the employee and various corporate interests, and corporate responsibility to consumers, society, and conservation of natural resources and the environment.

MGMT 692. Strategic Management. 3 credits, 3 contact hours.
This course focuses on the Strategic Integration of the different functional areas in management providing a top management perspective to the role of chief executive in an organization. An integral part of this course is to understand the roles of both competitive environment and the organization's experience in developing corporate strategy to gain competitive advantage. We also emphasize ethical issues related to corporate strategies.

MGMT 699. ST in Management. 3 credits, 3 contact hours.

MGMT 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: approval of the assistant dean for graduate programs. For students who desire to complete a thesis in management. Students must register every semester until the thesis is completed. Only 6 credits indicated for the thesis is applied to degree credit.

MGMT 710. Forecasting Methods for Business Decisions. 3 credits, 3 contact hours.
Covers the application of forecasting techniques to various phases of business and management decision making. Topics include forecasting with cyclical and seasonal series; Box-Jenkins modeling; regression modeling; use of stochastic models; and the linkage of management forecasts to macro forecasts. Actual models in use will be reviewed and evaluated.

MGMT 725. Independent Study. 3 credits, 3 contact hours.

MGMT 726. Independent Study II. 3 credits, 3 contact hours.

MGMT 735. Deep Learning in Business. 3 credits, 3 contact hours.
Prerequisites: FIN 620 or instructor's approval or advanced graduate standing. This course provides an in-depth study of data mining and machine learning, with a focus on business applications. As the business market becomes increasingly complicated and depends on data, analysts and fund managers must make better and faster decisions using available data. Data mining and machine learning make use of powerful tools and techniques to unlock the value inherent in available market data and routinely help managers uncover hidden patterns and correlations in data and gain insights to improve the decision-making in the market. The course is practice-oriented and develops the required skills to apply machine learning in the stock market and other business areas. Students will better understand the techniques for data mining and machine learning as well as gain hands-on knowledge of the contemporary analysis tools of data mining and machine learning. The course will enable students to better understand the major concepts, approaches, and techniques for data mining and machine learning. The included learning material provides adequate technical depth for students to know how data-driven technologies work. Coverage includes data mining and machine learning processes, methods, and techniques; the role and management of data; tools and metrics; and integration with Big Data.

MGMT 740. Innovation & Entrepreneurship. 3 credits, 3 contact hours.
Prerequisites: MGMT 640 (or equivalent) or permission of instructor. This course is designed to introduce the Ph.D. students to the extensive literature in innovation and entrepreneurship. The course builds on the early works by economists and sociologists, and progresses towards the most recent research. By discussing the early works and latest research, the course explores extant knowledge in Innovation and Entrepreneurship, the boundary conditions of the theories in Innovation and Entrepreneurship, and the possible avenues for future research.

MGMT 782. Business Research Methods II. 3 credits, 3 contact hours.

MIS 620. E-Commerce Technologies. 3 credits, 3 contact hours.
Intended to develop a basic understanding of the Internet and its underlying technologies as a foundation for e-commerce with an introduction to e-commerce applications. Addresses the technology for MIS managers to effectively manage the launching of e-commerce infrastructures. Covers data communication and networking, EDI, intranets and extranets, bandwidth and security issues.

MIS 625. Management Strategies for E-Commerce. 3 credits, 3 contact hours.
Prepares students for effective management of internet-based businesses and electronic commerce and oversight of global business activities in an increasingly competitive environment. Introduces Internet concepts and infrastructure. Examines current and proposed Internet services forming the basis of Internet commerce. Covers corporate intranets and extranets and their applications to corporate computing, seamless e-commerce, and other emerging services such as VPN. Issues are discussed, with special emphasis on security.

MIS 645. Information Systems Principles. 3 credits, 3 contact hours.
The management of information processing resources, including: role of information processing, estimates of personnel resources and budgets, integration of corporate and MIS plans, organizational alternatives for MIS departments and support staffs, management of computer operations, equipment and general software acquisitions, intermediate and long-range MIS plans, integration of personal computers, minicomputers, and mainframes, and security and controls.

MIS 648. Decision Support Systems for Managers. 3 credits, 3 contact hours.
Prerequisite: MIS 645. Covers the use of decision support systems to support management decision making in a real world environment. Topics include: establishing and measuring decision support systems success criteria, software tools, model management, elements of artificial intelligence, and statistics. Justification, design, and use of decision support systems.

MIS 680. Management Science. 3 credits, 3 contact hours.
Introduction to the methodology of decision making applying the techniques of operations research and system analysis to managerial problems. Introduction to the concept of objective functions and constraints, concepts of value and utilities, optimization algorithms, networks and game theories. Elementary mathematical model linear production systems, inventory systems, multi-criteria decision making, project management and transportation planning. Topics will be discussed from the deterministic as well as scholastic points of view.

MIS 685. Data Mgmt for Business Appl. 3 credits, 3 contact hours.
Prerequisite: Students must have taken a database course, such as MIS 385 or equivalent. This course introduces data management problems and technologies for business applications. It covers the concepts of relational database, data quality and cleaning, data warehouse and business intelligence, data integration, information extraction, data governance and security issues, and big data for managerial applications. Students will gain hands-on experience on data management through course assignments.

MIS 699. Selected Topics In Mis. 3 credits, 3 contact hours.

MIS 701. Thesis in Information Systems Management. 3 credits, 3 contact hours.
Prerequisites: MIS 645, MIS 648, CS 675, CS 679 or waived with approval of the Dean. Examines what is research? Why do research? What are the objectives of research? Covers need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

MIS 725. Independent Study. 3 credits, 3 contact hours.

MRKT 620. Competing in Global Markets. 3 credits, 3 contact hours.
Designed to help prepare students to become effective managers overseeing global market activities in an increasingly competitive environment. It will examine the impact of global economic, financial, cultural, political, and legal factors on the development of marketing programs and on the marketing/R&D and marketing/manufacturing interfaces.

MRKT 630. Models Of Consumer Behavior. 3 credits, 3 contact hours.
Provides students a framework, the buyer decision process model, to analyze how and why products and services are selected and purchased. Impact of consumer decisions on the marketing strategies of organizations is emphasized. Focus on quality management of the marketing function to determine customer needs; provide the appropriate products, prices, distribution systems, and promotion messages; and measure customer satisfaction after purchase and use.

MRKT 631. Marketing Research. 3 credits, 3 contact hours.
Provides a research and managerial perspective on advanced marketing research methods and analytical techniques. Topics include problem formulation, research design, data collection and analysis, managerial report writing. Students will acquire experience by developing and executing their own marketing research project using sophisticated computerized analytical techniques.

MRKT 632. Marketing Strategy for Technology-Based Organizations. 3 credits, 3 contact hours.
Prerequisite: MRKT 620. As technology continuously transforms products and business models and provides new competitive advantages that firms can capitalize on, this course introduces the marketing challenges of firms in the hyper-competitive environment. It provides students with an overview of marketing strategies: pricing, product, promotion, and place. Ethical issues are discussed as well as other course concepts using case analysis, videos, class discussion, and term projects.

MRKT 636. Design and Development of High Technology Products. 3 credits, 3 contact hours.
Focus on analysis of needs of buyers and consumers for specific product characteristics and the development of appropriate products to satisfy such needs. The process of identifying new product opportunities, screening new product concepts, product testing and test marketing, product positioning, and development of the marketing strategy and implementation plans.

MRKT 637. Marketing Communications and Promotions. 3 credits, 3 contact hours.
Communications, sales promotion, and public relations are examined from the perspective of the manager. Topics include advertising and promotion research, media selection, creative production of electronic and print materials, and the budgeting and control of their use. Field research will be stressed as part of the course project requirement.

MRKT 638. Sales Management for Technical Professionals. 3 credits, 3 contact hours.
Focuses on the promotion and sales of products in the business-to-organization market. All elements of the marketing communications mix are covered according to their importance in that market: selling, sales promotion, trade advertising, and publicity. The latest techniques are reviewed and discussed using case histories and student projects. Issues of global competitiveness, high technology products, and the role of total quality management in marketing communications are emphasized.

MRKT 642. International Marketing Management. 3 credits, 3 contact hours.
Focus on multinational enterprise in the global market, emphasizing special managerial skills required to adapt sound marketing practices to foreign cultural, political, economic and financial environments. Foreign opportunities and marketing strategies are examined. Students prepare a marketing plan for entry into an international market after conducting appropriate research.

MRKT 645. Internet Marketing Strategy. 3 credits, 3 contact hours.
Introduction to the use of the Internet and electronic commerce in the development of marketing strategy. Examines the characteristics of electronic markets, the use of Internet for data collection and market research, the Internet as a communication and distribution medium, and the development of Internet-based marketing strategies.

MRKT 725. Independent Study. 3 credits, 3 contact hours.

MRKT 753. Marketing Science. 3 credits, 3 contact hours.
Prerequisite: MRKT 631. Emphasizes quantitative model building approach to the complex problems of marketing decision making using the principles of quantitative decisions to management problems and econometrics to the understanding of large amounts of data, which lead to improvements in marketing decision effectiveness. Such areas of marketing as buyer behavior, pricing, promotion, advertising, sales force management, and new product planning will be analyzed.

Management

Master of Business Administration in Management of Technology

NJIT's MBA in the Management of Technology is designed to prepare a new generation of technology savvy business leaders.The curriculum integrates fundamental business knowledge with applications of technology to business to prepare students to think strategically about business and technology.The program is built upon four themes that are transforming business:

1. the transition to a knowledge based economy;
2. the emergence of the digital firm;

3. the globalization of business; and
4. innovation as the primary source of competitive advantage.

Concentration areas are offered in Management Information Systems, Marketing, and Finance.

Admission Requirements

Applicants to the MBA must submit complete transcripts of all undergraduate work and scores on the Graduate Management Admissions Test (GMAT).The GMAT is required of all applicants except those holding master's or doctoral degrees from an accredited U.S. university.Up to nine credits of graduate work may be transferred from another school, provided that they are not counted towards a terminal degree at that school.

MBA Pre-Qualifying Requirements : Students are expected to demonstrate competency in the area of accounting, finance, quantitive methods, information systems and economics.Depending on the applicant's undergraduate degree program all or part of the pre-qualifier requirements can be met with prior undergraduate course work.Applicants who do not meet pre-qualifying requirements will be required to complete a bridge course.

Master of Science in Management

The Master of Science in Management is designed to allow students to build specialized knowledge in one of four concentration areas : Management Information Systems, Organization Management, Management of Technology and Finance.Specialized knowledge is augmented with a 15 credit management core that provides the general knowledge needed to manage technical and specialized units.

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Executive Master of Business Administration

Tailored to the demanding schedules of working professionals, the solution focused 18-month, 48-credit program is customized for career advancement without interruption of professional obligations.Built upon the hallmarks of Innovation, Immersion, and Integration, this practical and results-oriented option emphasizes the application of advanced management strategies to traditional business challenges.With the added bonus of Saturdays and on-line flexibility, the EMBA offers both breadth and depth of business experience in an accelerated mode of delivery.Students are assigned independent and group projects emphasizing the employment of innovative management strategies in traditional corporate settings.Further, the students represent diverse industries and job functions, providing an enriching experience and balanced perspective.The curriculum consists of **4 Thematic Areas**: Leadership, Globalization, Creativity and Innovation, and Business and Government Relations.

EMBA candidates have the opportunity to participate in a 7-10 day international study tour.Meeting with business leaders in their work environments, students learn first-hand the opportunities and issues posed by today’s volatile-yet-exciting international business climate.Recent tours have included Brazil, France, The Czech Republic, Russia, Estonia, Chile, Argentina, and China. Students have called the trips “invaluable.” *[I gained] “critical insight….we would never have learned in any classroom or textbook.”*

Professional Leverage

The program offers the additional benefit of PMP or Risk Management certification training.This new program feature represents an integration of the EMBA with industry recognized professional qualifications.

Admission Requirements

These criteria are standard admission guidelines; however, each candidate is evaluated based upon his/her individual profile.

Candidates must have an earned bachelor’s degree (4 year US equivalent) and must take the GMAT (minimum score of 500); the GRE (with a comparable score) is also acceptable.

GMAT Waivers

- Candidates with an earned Master’s or PhD from a US or Canada based “accredited" program
- Candidates with a minimum GPA of 2.8 from a US based research intensive University
- Candidates [without masters degrees], who have “significant” management experience, may appeal to the EMBA admission committee for a GMAT waiver; **there is no waiver guarantee**.

Master of Science in International Business

The Master of Science in International Business is designed for students to gain an understanding of the activities in international business providing a framework for understanding them from the perspective of a company manager.The MSIB is a 30 credit program (which is 10 courses).

Admission Requirements

Applicants to the MSIB must submit complete transcripts of all undergraduate work and scores on the Graduate Management Admissions Test (GMAT).The GMAT is required of all applicants except those holding a master's or doctoral degree from an accredited U.S. university.Up to nine credits of graduate work may be transferred from another school, provided that they are not counted towards a terminal degree at that school.

MSIB Pre-Qualifying Requirements: Students are expected to demonstrate competency in the area of accounting, finance, quantitative methods, information systems, and economics.Depending on the applicant's undergraduate degree program all or part of the pre-qualifier requirements can be met with prior undergraduate course work.Applicants who do not meet pre-qualifying requirements will be required to complete up to 6 credits of course work.

NJIT Faculty

A

Anandarajan, Asokan, Professor

B

Bandera, Cesar, Assistant Professor

Bonitsis, Theologos H., Associate Professor

C

Casal, Jose C., Senior University Lecturer

Chakrabarti, Alok K., Distinguished Professor Emeritus

Chen, Yi, Associate Professor

Chou, Porchiung B., Senior University Lecturer

Cicon, James E., Assistant Professor

Cordero, Rene, Associate Professor Emeritus

E

Egbelu, Pius J., Distinguished Professor

Ehrlich, Michael A., Associate Professor

F

Fjermestad, Jerry L, Professor

G

Gopalakrishnan, Shanthi, Professor

Guilbault, Melodi D., Senior University Lecturer

K

Kudyba, Stephan P., Associate Professor

L

Lawrence, Kenneth, D., Professor

M

Mehta, Rajiv, Professor

P

Passerini, Katia, Professor

R

Rapp, William V., Research Professor

Rotter, Naomi G., Professor Emeritus

S

Schachter, Hindy L., Professor

Schoenebeck, Karen P., Senior University Lecturer

Shi, Junmin, Assistant Professor

Somers, Mark, Professor

Sverdlove, Ronald, Assistant Professor

Sylla, Cheickna, Professor

T

Thomas, Ellen J., Assistant Professor

W

Walsh, Diana, Senior University Lecturer

X

Xu, Wei, Assistant Professor

Y

Yan, Zhipeng, Associate Professor

Programs

- Management - M.S. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/)
- Management of Technology - M.B.A. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/)

Executive Program (http://catalog.njit.edu/archive/2019-2020/graduate/academic-policies-procedures/executive-program/)

- Management of Technology - E.M.B.A. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-emba/)

Business Data Science - Ph.D. (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/business-data-science-phd/)

Programs

- Finance for Managers (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/finance-for-managers-cert/)
- Management Essentials (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/management-essentials-cert/)
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This course explores the relationship between business and government with a focus on regulatory policies and public?private partnerships. Areas of focus include sustainability and environmental regulations, trade policies and their influence on international commerce, public policy concerning the Internet and emerging digital technologies, patent rights, and opportunities for public?private partnerships with regard to fostering economic development.

MGMT 660. Managing Supply and Value Chains. 3 credits, 3 contact hours.
This course is focused on the flow of products, information and revenue across supply and value chains in organizations. Special emphasis is placed on emerging e-business models and their effects on supply and value chains, and customer relationship management. The course also includes a survey of relevant information technologies.

MGMT 670. International Business. 3 credits, 3 contact hours.
Covers the scope and the essential characteristics of international business in the world economy; MNEs as economic, political, and social institutions; national and international control; functional management and operations; country evaluation; and regional market analysis.

MGMT 680. Entrepreneurial Strategy. 3 credits, 3 contact hours.
For the student who is considering starting and/or managing a new business. Integrates knowledge of the different aspects of business that have been learned as separate subjects. Provides an understanding of the decisions that guide the overall operations of an entrepreneurial business organization and how it interacts with its markets, competitors, and suppliers. Combines classroom instruction in business strategy along with case analysis of small firms. Should be taken in the last semester of the program, unless prior arrangement has been made with the instructor or the graduate advisor. Taken in the final semester only.

MGMT 682. Business Research Methods I. 3 credits, 3 contact hours.
A comprehensive introduction to business research methods covering the fundamental concepts of problem definition and the research process including quantitative and qualitative research, survey research, observation methods and experimental research methods. The course also covers data analytics, including advanced descriptive and predictive analysis models, involving inferential statistics, regression and correlation analyses and non-parametric methods. The course emphasizes problem solving using advanced quantitative software tools such as SPSS, Munitab, SAS, MathLab, and R. Students will be required to work on business research case studies and projects involving the collection and/or treatment of large data sets, as well as to develop research constructs and hypotheses and to write and present reports documenting research findings and recommendations.

MGMT 685. Operations Research and Decision Making. 3 credits, 3 contact hours.
Introduces the concepts of objective functions and constraints, concepts of value and utilities, optimization algorithms, networks, and game theory. Covers models of linear programming, inventory systems, multi-criteria decision-making, project management, and transportation planning. Topics discussed from probabilistic and deterministic approaches.

MGMT 686. Corporate Governance. 3 credits, 3 contact hours.
Presents inter-disciplinary perspectives on the rights, responsibilities and roles of the corporation in society. Focuses on the relationships among owners, managers, and other stakeholders. Analyzes corporate control mechanisms including ownership concentration, executive compensation, boards of directors, and the market for corporate control. Includes changes in political/legal/regulatory institutional environments over time, and develops a comparative international framework.

MGMT 688. Information Technology, Business and the Law. 3 credits, 3 contact hours.
Includes historical and constitutional foundations, crimes, and torts in cyberspace, virtual property (patents online, copyrights in digital information, trade secrets in cyberspace, and cybermarks), electronic commerce contracting, electronic commerce, electronic money and the law, and information technology and online infringement of rights of intellectual property.

MGMT 691. Legal and Ethical Issues. 3 credits, 3 contact hours.
Explores the legal and ethical responsibilities of managers. Analyzes extent to which shareholders should be allowed to exercise their legitimate economic, legal, and ethical claims on corporate managers; extent of regulation of a particular industry, individual rights of the employee and various corporate interests, and corporate responsibility to consumers, society, and conservation of natural resources and the environment.

MGMT 692. Strategic Management. 3 credits, 3 contact hours.
This course focuses on the Strategic Integration of the different functional areas in management providing a top management perspective to the role of chief executive in an organization. An integral part of this course is to understand the roles of both competitive environment and the organization's experience in developing corporate strategy to gain competitive advantage. We also emphasize ethical issues related to corporate strategies.

MGMT 699. ST in Management. 3 credits, 3 contact hours.

MGMT 701. Master'S Thesis. 0 credits, 0 contact hours.
Prerequisite: approval of the assistant dean for graduate programs. For students who desire to complete a thesis in management. Students must register every semester until the thesis is completed. Only 6 credits indicated for the thesis is applied to degree credit.

MGMT 710. Forecasting Methods for Business Decisions. 3 credits, 3 contact hours.
Covers the application of forecasting techniques to various phases of business and management decision making. Topics include forecasting with cyclical and seasonal series; Box-Jenkins modeling; regression modeling; use of stochastic models; and the linkage of management forecasts to macro forecasts. Actual models in use will be reviewed and evaluated.

MGMT 725. Independent Study. 3 credits, 3 contact hours.

MGMT 726. Independent Study II. 3 credits, 3 contact hours.

MGMT 735. Deep Learning in Business. 3 credits, 3 contact hours.
Prerequisites: FIN 620 or instructor's approval or advanced graduate standing. This course provides an in-depth study of data mining and machine learning, with a focus on business applications. As the business market becomes increasingly complicated and depends on data, analysts and fund managers must make better and faster decisions using available data. Data mining and machine learning make use of powerful tools and techniques to unlock the value inherent in available market data and routinely help managers uncover hidden patterns and correlations in data and gain insights to improve the decision-making in the market. The course is practice-oriented and develops the required skills to apply machine learning in the stock market and other business areas. Students will better understand the techniques for data mining and machine learning as well as gain hands-on knowledge of the contemporary analysis tools of data mining and machine learning. The course will enable students to better understand the major concepts, approaches, and techniques for data mining and machine learning. The included learning material provides adequate technical depth for students to know how data-driven technologies work. Coverage includes data mining and machine learning processes, methods, and techniques; the role and management of data; tools and metrics; and integration with Big Data.

MGMT 740. Innovation & Entrepreneurship. 3 credits, 3 contact hours.
Prerequisites: MGMT 640 (or equivalent) or permission of instructor. This course is designed to introduce the Ph.D. students to the extensive literature in innovation and entrepreneurship. The course builds on the early works by economists and sociologists, and progresses towards the most recent research. By discussing the early works and latest research, the course explores extant knowledge in Innovation and Entrepreneurship, the boundary conditions of the theories in Innovation and Entrepreneurship, and the possible avenues for future research.

MGMT 782. Business Research Methods II. 3 credits, 3 contact hours.

Executive M.B.A. in Technology

(48 credits)

Code	Title	Credits
Core Courses		
HRM 601	Organizational Behavior	3
ACCT 615	Management Accounting	3
FIN 600	Corporate Finance I	3
MRKT 620	Competing in Global Markets	3
ECON 610	Managerial Economics	3
MGMT 630	Decision Analysis	3
MIS 645	Information Systems Principles	3
MGMT 692	Strategic Management	3
Total Credits		24

Concentration in Business and Government Relations

Code	Title	Credits
MGMT 656	Public Policy and Business	3
MGMT 686	Corporate Governance	3
Total Credits		6

Concentration in Global Business

Code	Title	Credits
MGMT 641	Global Project Management	3
MGMT 670	International Business	3
Total Credits		6

Concentration in Innovation and Business Development

Code	Title	Credits
MGMT 649	Convention, Creativity and Innovation	3
MGMT 640	New Venture Management	3
MGMT 650	Knowledge Management	3

FIN 655	Financial Innovations and Market Failures	3
Total Credits		12

Finance for Managers

The courses use shared business cases and a shared knowledge base that are accessible throughout the certificate program. The common cases and knowledge base allow students to review material from courses that they have completed and provide an integrated perspective to business problems. Credential relates in its entirety to either NJIT MBA or NJIT MS in Management.

Who would be suited to take this program?

This 12 credit graduate certificate was created to offer managers and professionals core business knowledge in the areas of corporate and international finance.It is designed to provide the skill and tools needed to analyze business models and to apply core business concepts to tactical and strategic problems.This includes advanced skills and tools to analyze business conditions and tactically solve problems and Finance and Management Accounting.

What are the Required Courses?

Code	Title	Credits
Core Courses		
ACCT 615	Management Accounting	3
FIN 600	Corporate Finance I	3
FIN 624	Corporate Finance II	3
Electives		
Select one of the following:		3
FIN 627	International Finance	
FIN 634	Mergers, Acquisitions, and Restructuring	

What will I learn?

- Management accounting builds on traditional concepts of managerial accounting (break-even analysis, alternate choice decisions, profit planning, and transfer pricing) and develops the skills that an executive needs in strategic cost analysis.
- Financial and economic environment discusses issues related to interest rates, extraordinary rates of inflation, fiscal and monetary policy, and regulatory policy are integrated with market structure, cost and production technology, pricing policy, cash flow, risk-return opportunities, capital budgeting techniques, and decision making in companies.
- Financial management of assets, liabilities and equity in a domestic framework. Includes: goals of the firm, time value of money, financial statement analysis, financial ratio analysis, financial planning and forecasting, capital budgeting, cost of capital, capital structure, dividend policy, working capital management, mergers and acquisitions, and pricing of options.
- International finance examines financing of exports and imports, managing multi-currency working capital, international aspects of capital budgeting, cost of capital and their relationship with political, economic, and financial risk.Explores financial innovations and their impact on the firm's financial strategy and performance of overall productivity. Discusses the tax consequences and principal-subsidiary relationship of the multinational enterprise. Introduces international money and capital markets, instruments, derivatives, and institutions.
- Mergers, acquisitions, and restructuring focuses on identifying and evaluating potential and international companies for mergers and acquisitions as well as structuring of deals.The financial, social and managerial implications of these changes in corporate ownership will be examined.Topics are: financing M&As, deal structuring, tax implications, valuation, broker/finder agreements, merger negotiations, and post-merger integration.

Why study Finance for Managers at NJIT?

The graduate certificate’s narrow focus allows you to dig deep into this specific topic, and start applying your knowledge sooner.It is possible to earn this certificate entirely through online courses, so you can more easily fit it into your busy life.And whether you take courses online or on campus you’ll learn from NJIT’s distinguished professors and instructors from the School of Management.

Prerequisites

Completion of a Bachelor’s degree with a overall cumulative Grade Point Average of 2.8 or higher on a 4.0 scale.

Related Degree Programs

All credits for this certificate apply to the NJIT MBA (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/)

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/finance-managers-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Shanthi Gopalakrishnan (http://directory.njit.edu/PersDetails.aspx?persid=sgopalak)

FINANCIAL TECHNOLOGY

(12 credits)

Fintech (Financial Technology) is at the intersection of technology and financial services. FinTech has recently helped the finance industry make big strides by taking advantage of evolving technologies. Offered by the Martin Tuchman School of Management, the Graduate Certificate in Financial Technology is suitable for students interested in corporate finance logistics who want to acquire knowledge for building technical applications to enhance or create innovative processes in finance.

Who would be suited to take this program?

There are primarily two types of people that would benefit the most from this program: technology-oriented managers who want to understand the underpinnings of applications in the finance industry and application developers who want to embrace the financial world.

Required course:

Code	Title	Credits
FIN 600	Corporate Finance I	3

Choose three courses:

Code	Title	Credits
FIN 611	Intro to Topics in Fin Tech	3
FIN 616	Data Driven Financial Modeling	3
FIN 620	Adv Financial Data Analytics	3
FIN 624	Corporate Finance II	3
FIN 626	Financial Investment Institutions	3
FIN 641	Derivatives Markets	3
MGMT 635	Data Mining and Analysis	3

M.B.A. in Management of Technology

Code	Title	Credits
Bridge Course		
MGMT 501	Management Foundations	3
Total Credits		3

Code	Title	Credits
Module I [1]		
ACCT 615	Management Accounting	3
FIN 600	Corporate Finance I	3
FIN 610	Global Macro Economics	3
or ECON 610	Managerial Economics	
HRM 601	Organizational Behavior	3
MGMT 691	Legal and Ethical Issues	3
MIS 645	Information Systems Principles	3
or IS 677	Information System Principles	
MIS 680	Management Science	3
or MGMT 630	Decision Analysis	
MRKT 620	Competing in Global Markets	3
MGMT 692	Strategic Management	3
or MGMT 680	Entrepreneurial Strategy	
Module II Elective Core Courses		

Select three of the following:		9
MGMT 620	Management of Technology	
MGMT 635	Data Mining and Analysis	
MGMT 640	New Venture Management	
MGMT 650	Knowledge Management	
MGMT 670	International Business	
MGMT 699	ST in Management	
MIS 648	Decision Support Systems for Managers	
EM 636	Project Management	
HRM 630	Managing Technological and Organizational Change	
Module III Concentration Courses		
Select four courses in one concentration:		12
MIS Concentration Courses [1]		
MGMT 630	Decision Analysis	
MGMT 635	Data Mining and Analysis	
MGMT 641	Global Project Management	
MGMT 710	Forecasting Methods for Business Decisions	
MIS 648	Decision Support Systems for Managers	
IS 631	Enterprise Database Management	
IS 663	System Analysis and Design	
IS 678	IT Service Management	
IS 684	Business Process Innovation	
IS 688	Web Mining	
Finance Concentration Courses		
FIN 610	Global Macro Economics	
FIN 624	Corporate Finance II	
FIN 626	Financial Investment Institutions	
FIN 627	International Finance	
FIN 634	Mergers, Acquisitions, and Restructuring	
FIN 641	Derivatives Markets	
FIN 642	Derivatives and Structured Finance	
FIN 650	Investment Analysis and Portfolio Theory	
Marketing Concentration Courses		
MRKT 631	Marketing Research	
MRKT 636	Design and Development of High Technology Products	
MRKT 638	Sales Management for Technical Professionals	
MNE 655	Concurrent Engineering	
MGMT 625	Distribution Logistics	
IE 659	Supply Chain Engineering	
IS 664	Customer Discovery	
Healthcare Management Concentration Courses		
MGMT 635	Data Mining and Analysis	
MIS 648	Decision Support Systems for Managers	
CS 631	Data Management System Design	
CS 632	Advanced Database System Design	
CS 634	Data Mining	
CS 639	Elec. Medical Records: Med Terminologies and Comp. Imp.	
BNFO 615	Data Analysis in Bioinformatics	
BNFO 644	Data Mining and Management in Bioinformatics	
MATH 663	Introduction to Biostatistics	
IE 686	Intro to Healthcare Systems	
IE 687	Healthcare Enterprise Systems	

IE 688	Healthcare Sys Perfor Modeling	
MGMT 650	Knowledge Management	
Cooperative Education		
Innovation and Entrepreneurship Concentration Courses		
MGMT 625	Distribution Logistics	
MGMT 640	New Venture Management	
MGMT 645	New Venture Finance	
MGMT 649	Convention, Creativity and Innovation	
MGMT 688	Information Technology, Business and the Law	
MRKT 636	Design and Development of High Technology Products	
HRM 630	Managing Technological and Organizational Change	
Custom Concentration		
Select 4 elective courses		
STEM-MBA Option Concentration		
Select 4 elective courses		
Total Credits		48

1 All courses required. No substitutions.

Management Essentials

This four course module uses shared business cases and a shared knowledge base that are accessible throughout the certificate program, allowing students to review material from courses that they have completed and providing an integrated perspective to business solutions. Course delivery and material include online lectures accessible over the Internet, threaded discussions, online chat in real time and case analyses as each course has the same user interface, all courses have the same look and feel allowing students to move seamlessly from course to course.

Who is suited for this program?

This 12 credit graduate certificate was created to offer managers and professionals core business knowledge in the areas of finance, marketing, accounting, and management information systems. It is designed to provide the skill and tools needed to analyze business models and to apply core business concepts to tactical and strategic problems.This includes advanced skills and tools to analyze business conditions and tactically solve problems.

What are the Required Courses?

Code	Title	Credits
Core Courses		
ACCT 615	Management Accounting	3
FIN 600	Corporate Finance I	3
MRKT 620	Competing in Global Markets	3
MIS 645	Information Systems Principles	3

What will I learn?

- Management Accounting builds on traditional concepts of managerial accounting (break-even analysis, alternate choice decisions, profit planning, and transfer pricing) and develops the skills that an executive needs in strategic cost analysis.
- Corporate Finance introduces concepts and analytical tools to identify and solve financial management problems. This course focuses on how companies invest in real assets and how they raise the money to pay for those assets. The course also examines pricing theory and capital structure
- Competing in Global Markets examines the impact of global economic, financial, cultural, political, and legal factors on the development of marketing programs and on the marketing/R&D and marketing/manufacturing interfaces.
- Information Systems Principles incorporates he management of information processing resources, including: role of information processing, estimates of personnel resources and budgets, integration of corporate and MIS plans, organizational alternatives for MIS departments and support staffs, management of computer operations, equipment and general software acquisitions, intermediate and long-range MIS plans, integration of personal computers, minicomputers, and mainframes, and security and controls.

Why study Management Essentials at NJIT?

The graduate certificate’s directed focus allows you to dig deep into this specific topic, and immediately apply your knowledge. It is possible to earn this certificate entirely through online courses, so you can more easily fit it into your busy life. And whether you take courses online or on campus you’ll learn from NJIT’s distinguished professors and instructors from the Martin Tuchman School of Management.

Prerequisites

Completion of a Bachelor’s degree with a overall cumulative Grade Point Average of 2.8 or higher on a 4.0 scale.
GRE or GMAT; minimum score of 500 or equivalent GRE score. Applicants with a minimum GPA of 2.8 from a U.S.-based research institution and candidates with a Master's or Ph.D. degrees from a U.S. or Canada-based accredited program may qualify for a GMAT or GRE waiver

Related Degree Programs

All credits for the Management Essential Certificate relates in its entirety to either NJIT MBA (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/), NJIT MS in Management (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/), or NJIT MS in Business and Information Systems (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-ms/).

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/management-essentials-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Advisor: Cheickna Sylla (http://directory.njit.edu/PersDetails.aspx?persid=sylla)

Management of Technology

With the use of technology on a constant rise, NJIT recognizes the demand for highly trained individuals to manage the influence of technology in organizations and the global market place.

Who is suited for this program?

The Management of Technology Graduate Certificate provides students with the skills and tools needed to manage organizational change, both planned and unplanned, associated with existing and emerging technologies.Two core courses, Management of Technology and Managing Technological and Organizational Change, provide students with the background for integrating fundamental business knowledge with applications of technology.The focus is on the generation, development and implementation of technology as well as the influences of technology on global competitiveness.Students select two electives that are consistent with their learning and career goals.

What are the Required Courses?

Code	Title	Credits
Core Courses		
Select four of the following:		12
EM 636	Project Management	
HRM 601	Organizational Behavior	
MGMT 620	Management of Technology	
MGMT 650	Knowledge Management	
MIS 645	Information Systems Principles	
MIS 648	Decision Support Systems for Managers	

What will I learn?

- Technology as a main component of an organizational entity. Generation, development, and implementation of technology are outlined. Influence of technology on global competitiveness is also discussed.
- Managing Technological and Organizational Change which Focuses on planned and unplanned systemic change, such as downsizing, re-engineering, mergers, and acquisitions.
- Knowledge Management where students will have a comprehensive framework for designing and implementing a successful knowledge management effort and be able to assist in the development of knowledge.
- Information Systems Principles which discusses the role of information processing, estimates of personnel resources and budgets, integration of corporate and MIS plans, organizational alternatives for MIS departments and support staffs, management of computer operations, equipment and general software acquisitions, intermediate and long-range MIS plans, integration of personal computers, minicomputers, and mainframes, and security and controls.
- Decision Support Systems which covers the use of decision support systems to support management decision making in a real world environment.

- E-Commerce Technologies which develops a basic understanding of the Internet and its underlying technologies as a foundation for e-commerce with an introduction to e-commerce applications.
- Management Strategies for E-Commerce which prepares students for effective management of internet-based businesses and electronic commerce and oversight of global business activities in an increasingly competitive environment.
- Managing the Digital Firm which includes managing a virtual workforce, managing digital technologies, and protecting and leveraging digital assets.

Why study Management of Technology at NJIT?

The graduate certificate's narrow focus allows you to dig deep into this specific topic, and start applying your knowledge sooner. It is possible to earn this certificate entirely through online courses, so you can more easily fit it into your busy life.And whether you take courses online or on campus you'll learn from NJIT's distinguished professors and instructors from the School of Management.

Prerequisites

Completion of a Bachelor's degree with a overall cumulative Grade Point Average of 2.8 or higher on a 4.0 scale.

Related Degree Programs

All credits for the Management of Technology Certificate relates in its entirety to either NJIT MBA (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/technology-mba/), NJIT MS in Management (http://catalog.njit.edu/archive/2019-2020/graduate/management/management/ms/), or the MS in Business and Information Systems (http://catalog.njit.edu/archive/2019-2020/graduate/computing-sciences/information-systems/business-information-systems-ms/).The MS in Management can be completed entirely online in limited formats, and the Management of Technology graduate certificate program is a great way to jump start into the program.

Gainful Employment Disclosure

Click here (http://www.njit.edu/graduatestudies/sites/graduatestudies/files/gainfulemployment/management-technology-cert-gainful-employment.html) for the Gainful Employment Disclosure for this program

Faculty Adviser: Cheickna Sylla (http://directory.njit.edu/PersDetails.aspx?persid=sylla)

Master of Science in Management (MSM)

The MSM program blends technical expertise with fundamental management knowledge.

Concentration Areas:

- Business Analytics
- Global Project Managment
- Web Systems and Media
- Financial Technology (FinTech)

Management: The Next Step for Professionals with Technical Backgrounds

At some point in their careers, successful professionals are faced with the prospect of moving into managerial positions as the next logical step in their career progressions.The MSM program is designed to facilitate this transition.It is more focused than is the MBA curriculum through a stronger emphasis on mastery of a clearly defined concentration area.

The MSM is best suited for candidates who wish to have more influence in their organizations by moving into managerial positions, but who also desire to retain their allegiance to an area of technical expertise.

A Fast Tracked Program for Fast Tracked Professionals

The MSM program is delivered with special attention to people on the move.Students can complete the degree requirements in two years of part-time study or in a single year of full-time study.Courses are offered during the evenings to accommodate the schedules of working professionals.In addition, the 15-credit MSM core is available on-line.

MS in Management Curriculum

The **Master of Science in Management** is a 30 credit program that prepares graduates for managerial roles in organizations. Its emphasis is on melding business fundamentals and technical knowledge within specific areas of concentration including Business Analytics, Global Project Management, and Web Systems and Media, and **Financial Technology (FinTech)**.

Code	Title	Credits
Bridge Course		
MGMT 501	Management Foundations	3

Code	Title	Credits
Core Courses		
ACCT 615	Management Accounting	3
FIN 600	Corporate Finance I	3
HRM 601	Organizational Behavior	3
MIS 645	Information Systems Principles	3
or IS 677	Information System Principles	
MRKT 620	Competing in Global Markets	3
Select 15 credits from one area:		15
Global Project Management [1]		
ECON 610	Managerial Economics	
or FIN 610	Global Macro Economics	
EM 636	Project Management	
EM 637	Project Control	
EM 691	Cost Estimating for Capital Projects	
IE 618	Engineering Cost and Production Economics	
IE 659	Supply Chain Engineering	
IS 614	Command and Control Systems	
IS 684	Business Process Innovation	
MGMT 641	Global Project Management	
Web Systems and Media [2]		
IS 661	User Experience Design	
IS 664	Customer Discovery	
IS 688	Web Mining	
IS 690	Web Services and Middleware	
MRKT 637	Marketing Communications and Promotions [4]	
PTC 601	Advanced Professional and Technical Communication	
PTC 605	Elements of Visual Design	
PTC 606	Advanced Information Design	
PTC 650	eLearning Design for Mobile	
Business Analytics [3]		
CS 634	Data Mining	
IS 631	Enterprise Database Management	
IS 687	Transaction Mining and Fraud Detection	
IS 688	Web Mining	
MATH 661	Applied Statistics	
MGMT 625	Distribution Logistics	
MGMT 630	Decision Analysis	
MGMT 635	Data Mining and Analysis	
MGMT 650	Knowledge Management	
MGMT 710	Forecasting Methods for Business Decisions	
MIS 648	Decision Support Systems for Managers	
MRKT 645	Internet Marketing Strategy	
Financial Technology [4]		
FIN 611	Intro to Topics in Fin Tech	
FIN 616	Data Driven Financial Modeling	
FIN 620	Adv Financial Data Analytics	
MGMT 735	Deep Learning in Business	
FIN 641	Derivatives Markets	

FIN 626	Financial Investment Institutions	
FIN 624	Corporate Finance II	
MGMT 635	Data Mining and Analysis	
Total Credits		30

[1] One course must be either ECON 610 Managerial Economics or MGMT 641 Global Project Management
[2] One course must be MRKT 637 Marketing Communications and Promotions
[3] One course must be MGMT 630, MGMT 635, MGMT 710, MIS 648, or MRKT 645.
[4] One course must be FIN 611 and two courses must be FIN 616, FIN 620 and MGMT 735

The MSM curriculum puts it all together and prepares managers who know how to use technology to meet strategic objectives; who have business smarts; and who can meet the growing demand for technology savvy leadership

Curriculum Structure & Content

The MSM curriculum is divided into two modules: the business core and concentration area.The business core comprises one-half (15 credits) of the degree requirements with the remaining 15 credits focusing on the concentration's management knowledge component.

The Business Core: The business core provides the fundamental business knowledge needed to evaluate business models and to assume managerial positions.Coursework includes key functional areas in business: accounting, finance, marketing, information systems, leadership and organizational behavior.

Management Concentration Area: Each student selects a management area with a technical focus for in-depth study. Concentration courses are designed to complement the concepts offered in the 15 credit business core. Current concentration areas include: Business Analytics, Global Project Management, and Web Systems and Media, and **Financial Technology (FinTech)**.

Management Concentrations

Each student must select an area of concentration.The concentration consists of 5 classes for a total of 15 credits.

Global Project Management

What is Global Project Management about?

The Global Project Management specialization is focused on Manufacturing, Construction, Supply Chain, and Business Process Management. The areas include the expertise of the engineering resource planning function such as Production Planning, Global Project Planning, Engineering Management, and Construction Planning and Control.

Who is it for?

Professionals who are interested in the field of complex Project Management, relationship facilitation and coordination between project teams and customers, and harmonizing the demands among project scope, time, expenditures and quality of the end product.Many students who select Global Project Management have undergraduate degrees in International Business, Civil Engineering, and Architecture, and are seeking a career focused more on corporate and project management fields.

Where Can It Take Me?

Career tracks begin with managing focused projects and leading to work on larger international and national projects.Global Project Management professionals would then transition into managerial roles and run Operations departments. Sustained career progress tracks to the COO position.

Business Analytics

What is Business Analytics?

The Business Analytics specialization is focused on business development, solutions, product development and analysis of the customer requirements.Prized skills include expertise in business forecasting, project costing and accounting, business development, and structured solutions to customer complex business problems.

Who is it for?

Candidates who are interested in business solutions, consultation, business development and strategies, and infrastructure and planning management. Many students who select business analytics have undergraduate degrees in Engineering, Technology, and Applied Science and are seeking a career focused on business solutions development and management.

Where Can It Take Me?

The career track begins with managing focused projects as business analysts with technological, solution provider, governmental, and non-profit organizations. Business analysts then transition into managerial roles and lead business development teams. Sustained career progress tracks to the director of operations, COO and CTO.

Web Systems and Media

What is Web Systems and Media?

The Web Systems and Media specialization is focused on the development of a revolutionized way of web applications and social media applications. They include expertise in marketing strategies, front end – user experience analysis, SEO (Search Engine Optimization) management, and working closely with development teams for final product design.

Who is it for?

Candidates who are interested in web development, graphics development, media and journalism, and online marketing strategy development. Many students who select Web Systems and Media have undergraduate degrees in Information Technology, Computer Science, Journalism, Graphic design, and professional and technical communications.

Where Can It Take Me?

The career track begins with work on focused projects as front end developer or content developer supporting web development teams. Web Systems and Media professionals then move into managerial roles, leading project development teams. Sustained career progress tracks to project lead and CTO.

Financial Technology

What is Financial Technology?

Financial Technology (FinTech) is a rapidly growing subsector of the financial services industry, which involves the application of new technologies including software tools, networking, user experience and interface platforms, and modern modeling and analytical techniques to improve the efficiency and deployment of traditional financial services. The rapid increase in the quantity, variety, and availability of new data and information sources has fundamentally changed legacy business practices in the financial services industry. Big data creates an increasing market need for talents who utilize new technologies and innovations to understand hidden patterns in investor habits and market behaviors as well as assist managers in making informed data-driven decisions. The requisite skillset required to process and analyze such information has resulted in considerable demand for staff with software development, mathematical and statistical modeling, and practical problem solving expertise. New financial technologies include, but are not limited to, crypto-currencies (e.g., bitcoin), blockchain, cloud computing, retail banking automation, machine learning and deep learning, automated investment advisement, algorithmic trading, and risk management framework development and associated visualization tools.

Who is it for?

Students who are interested in applying modern tools to improve financial activities, design new applications, processes, products or business models related to financial services. Typically, students who undertake the FinTech concentration have obtained undergraduate degrees in Engineering, Technology, Finance or the applied sciences and are seeking a career focused on applying technical tools for the development of new financial services.

What are Potential Career Prospects in FinTech?

There are various career paths one may pursue after completing the FinTech concentration. In particular, careers in finance, technology, and entrepreneurship such as investment banking, international finance, commercial banking, sales and trading, information technology, social entrepreneurship, etc. are vocations within the scope of this program. Graduates may work for FinTech startups as well which concentrate in cryptocurrency management and trading, blockchain technologies including smart contracts, open banking, insurtech, Robo-advisement, machine learning and data mining applications and cybersecurity. Some may work for traditional financial services companies, which are in need of staff with technical skillsets to improve existing business practices and/or develop new processes related to technological innovations.

Ph.D in Business Data Science

Ph.D. in Business Data Science

Degree Requirements

Ph.D. students in Business Data Science (BDS) are expected to conduct innovative and independent research and have their research findings published in peer-reviewed scholarly journals and academic conference proceedings.

By the beginning of the first semester, upon the approval of the Ph.D. program director, student must have filed a Plan of Study (POS) that lists the courses to be taken and the timeline of study. Any modification to the POS must be approved by the Ph.D. program director and dissertation advisor (if chosen).

Course Requirements

By the end of year one, student must have completed any assigned bridge courses upon the PhD program academic advisor's suggestion with a grade of at least a B in each course. The list of bridge courses are:

- Programming and data structure (e.g. NJIT CS 280 or CS 505)
- Advanced Calculus (e.g. NJIT Math 211)
- Probability and Statistics (e.g. NJIT MGMT 216 or Math 333)
- Basic business knowledge (e.g. NJIT MGMT 492, MGMT 501)

A student entering the program with only a Bachelor's degree in related areas shall take 36 credits of advanced courses beyond the Bachelor's degree with the approval of the PhD program academic advisor. The 36 credits shall include six core courses and six elective courses, and are in addition to the credits for dissertation research. Among the 36 credits, at least 12 credits must be of the 700 level courses or courses with PhD track projects.

A student entering the program with a Master's degree or above in the related areas shall take 18 credits of advanced courses beyond the Master's degree or its equivalent with the approval of the PhD program academic advisor. These 18 credits are in addition to the credits for dissertation research. Among the 18 credits, at least 12 credits must be of the 700 level courses or courses with PhD track projects.

All core courses are listed in Table DR-1. Among them, MGMT 682 is a pre-requisite of MGMT 782. Typically, MGMT 682, Math 660 and Math 644 are only offered in the Fall semesters.

Table DR-2 provides a partial list of the elective courses available to program students. In addition to the listed elective courses, a student may take other relevant courses, subject to the approval of the dissertation advisor and Ph.D. program director.

Code	**Title**	**Credits**
Table DR-1: List of Core Courses		
MGMT 682	Business Research Methods I	3
MGMT 782	Business Research Methods II	3
MGMT 635	Data Mining and Analysis	3
or CS 634	Data Mining	
CS 631	Data Management System Design	3
or IS 631	Enterprise Database Management	
MATH 660	Introduction to statistical Computing with SAS and R	3
MATH 644	Regression Analysis Methods	3

Code	**Title**	**Credits**
Table DR-2: List of Elective Courses		
ACCT 615	Management Accounting	3
CS 610	Data Structures and Algorithms	3
CS 632	Advanced Database System Design	3
CS 675	Machine Learning	3
or CS 732	Advanced Machine Learning	
CS 750	High Performance Computing	3
CS 645	Security and Privacy in Computer Systems	3
or CS 708	Advanced Data Security and Privacy	
CS 666	Simulation for Finance	3
ECE 601	Linear Systems	3
ECE 673	Random Signal Analysis I	3
ECON 610	Managerial Economics	3
EM 655	Management Aspects of Information Systems	3
FIN 600	Corporate Finance I	3
FIN 610	Global Macro Economics	3
FIN 624	Corporate Finance II	3
FIN 626	Financial Investment Institutions	3

FIN 627	International Finance	3
FIN 634	Mergers, Acquisitions, and Restructuring	3
FIN 641	Derivatives Markets	3
FIN 650	Investment Analysis and Portfolio Theory	3
FIN 655	Financial Innovations and Market Failures	3
HRM 601	Organizational Behavior	3
HRM 630	Managing Technological and Organizational Change	3
IE 650	Advanced Topics in Operations Research	3
IE 687	Healthcare Enterprise Systems	3
IE 688	Healthcare Sys Perfor Modeling	3
IS 634	Information Retrieval	3
IS 665	Data Analytics for Info System	3
IS 682	Forensic Auditing for Computing Security	3
IS 684	Business Process Innovation	3
IS 687	Transaction Mining and Fraud Detection	3
IS 688	Web Mining	3
MATH 699	Design and Analysis of Experiments	3
MGMT 620	Management of Technology	3
MGMT 630	Decision Analysis	3
MGMT 640	New Venture Management	3
MGMT 641	Global Project Management	3
MGMT 649	Convention, Creativity and Innovation	3
MGMT 656	Public Policy and Business	3
MGMT 670	International Business	3
MGMT 680	Entrepreneurial Strategy	3
MGMT 688	Information Technology, Business and the Law	3
MGMT 691	Legal and Ethical Issues	3
MGMT 692	Strategic Management	3
MGMT 710	Forecasting Methods for Business Decisions	3
MIS 625	Management Strategies for E-Commerce	3
MIS 645	Information Systems Principles	3
MIS 648	Decision Support Systems for Managers	3
MIS 680	Management Science	3
MRKT 620	Competing in Global Markets	3
MRKT 631	Marketing Research	3
MRKT 636	Design and Development of High Technology Products	3
MRKT 637	Marketing Communications and Promotions	3
PTC 628	Analyzing Social Networks	3

GPA

Students must maintain a cumulative GPA of 3.0 or higher.

Qualifying Examination

All Ph.D. students are required to take a Qualifying Examination (Part-1) by the end of year one, and must pass the Qualifying Examination (Part-1) by the end of year two. The Qualifying Examination (Part-1) covers subject matter drawn from the core courses.

All Ph.D. students are required to take Qualifying Examination (Part-2) by the end of year two, which covers a subject area chosen by the student based on his/her dissertation research area.

Dissertation Requirements

Besides the classroom course requirements, students shall also take the following courses for Ph.D. dissertation requirements.

Ph.D. students are required to register each semester for a zero-credit course: BDS 791 Graduate Seminar. Full-time students must attend all BDS 791 seminars each semester unless justifiable reasons are approved by the program director in advance. Part-time students must attend at least 50% of the BDS 791 seminars in their first year. After their first year, they can perform alternative work as assigned by the program director in lieu of attending seminars.

The requirement of pre-doctoral research (BDS 792B) and doctoral dissertation (BDS 790B) credits are described at: http://www5.njit.edu/graduatestudies/content/new-phd-credit-requirements/. Specifically,

- Ph.D. students who pass the Qualifying Examination (part-1) must then register for 3 credits of pre-doctoral research (BDS 792B) per semester until they defend successfully the dissertation proposal
- Ph.D. students who defend the dissertation proposal successfully must then register for the 1-credit dissertation course (BDS 790A) each semester until they complete all degree requirements.

Students may take courses simultaneously with the 790 or 792 course as per Ph.D. program guidelines or dissertation committee recommendation.

Dissertation Advisor

Students are recommended to choose a dissertation advisor as soon as possible, but no later than 3 months after passing the Qualifying Exam (part-1).

Dissertation Proposal

A dissertation committee must be established, and the dissertation proposal must be defended successfully either by the end of the third year in the Ph.D. program or four semesters after registering for the first time in the 792 pre-doctoral research course, whichever occurs earlier.

Dissertation Defense

Full-time PhD students must defend the dissertation successfully by the end of the sixth year in the PhD program.

Please refer to the following website for other Institution-wide policies and procedures for Ph.D. programs: (http://www5.njit.edu/graduatestudies/sites/graduatestudies/files/policies-procedures-doctoral_updated_2015.pdf)http://www5.njit.edu/graduatestudies/sites/graduatestudies/files/policies-procedures-doctoral_updated_2015.pdf

Index

E

F

G

H

I

L

M

R

S

T

U

Y