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/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 Emeritus

Bandelt, Matthew, Assistant Professor

Borgaonkar, Ashish, Assistant Professor, Engineering Technology (Joint Faculty)

Boufadel, Michel, Professor

C

Chien, I Jy, Steven, Professor

Cianci, Andrew, Senior University Lecturer

D

Daniel, Janice R., Professor

Dauenheimer, Edward G., Professor Emeritus

Dimitrijevic, Branislav, Assistant Professor

Ding, Yuan, Associate Professor

Dresnack, Robert, Professor Emeritus

G

Greenfeld, Joshua S., Professor Emeritus

H

Hsieh, Hsin-Neng, Professor Emeritus

K

Karaa, Fadi A., Associate Professor

Khera, Raj P., Professor Emeritus

Konon, Walter, Professor

L

Lee, Joyoung, Associate 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

Pennock, William, Assistant Professor

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, Senior 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/graduate/newark-college-engineering/civil-environmental/civil-ms/)
- Civil Engineering - M.S. online (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/civil-ms-online/)
- Critical Infrastructure Systems - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/critical-infrastructure-systems-ms/)

- Environmental Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-ms/)
- Transportation - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/transportation-ms/)

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

- Architecture - M.Arch. and Civil Engineering - M.S. (http://catalog.njit.edu/graduate/architecture-design/architecture/march-civil-engineering-ms/)

Programs

- Civil Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/civil-phd/)
- Environmental Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-phd/)
- Transportation - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/transportation-phd/)

Programs

- Climate Change Adaptation and Resilience (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/climate-change-adaptation-and-resilience-cert/)
- Construction Management (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/construction-management-cert/)
- Environmental Engineering (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-engineering-studies-cert/)
- Geotechnical Engineering (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/geotechnical-cert/)
- Hydrology and Water Resources Engineering (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/hydrology-and-water-resources-engineering-cert/)
- Intelligent Transportation Systems (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/intelligent-transportation-systems-cert/)
- Structural Engineering (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/structural-engineering-cert/)
- Transportation Studies (http://catalog.njit.edu/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 612. Machine Learning and Data Analytics for Civil Engineering Systems. 3 credits, 3 contact hours.
Prerequisites: CS 101, MATH 211, and MATH 279, or approval of instructor. This course provides students with hands-on and fundamental knowledge of machine learning, data science, and data mining methodologies for scraping, manipulating, transforming, cleaning, visualizing, summarizing, and modeling large-scale data in civil engineering and infrastructure systems using analytical tools. This course includes data management and analysis, data wrangling and exploration, unsupervised learning, pattern recognition, supervised learning for classification and regression purposes, data preprocessing, and model training and evaluation. Students will explore the capabilities of these concepts in addressing the challenging and interesting problems in the field of civil engineering, and they will develop skills to apply these techniques to solve multiple real-world civil engineering problems. Python programming language will be introduced and used throughout this course to illustrate practical examples and to show students how to apply the learned techniques in the civil engineering practice.

CE 613. Resilient Systems Planning and Design. 3 credits, 3 contact hours.
Prerequisites: CS 101, MATH 211, MATH 279, CE 320, or approval of instructor. This course provides an overview of natural hazards and resilient systems planning and design with a focus on flood-related considerations. This course reviews state-of-the-art responses to disasters and floods, the limitations of traditional resilience approaches, and recent developments in floodproofing and retrofitting solutions according to the requirements and recommendations provided by the Federal Emergency Management Agency (FEMA) and the American Society of Civil Engineers (ASCE). The course further discusses the different physical, economic, and social impacts of disasters on infrastructures, communities, and economies as well as presents contemporary considerations in resilience risk management, planning, and design. The course also examines how to assess, measure, model, and quantify uncertainty and resilience as well as perform sound economic analysis and make informed decisions for flood mitigation projects. Case studies of critical infrastructure resilience, floodproofing, and other natural disaster-related events, impacts, and strategies are discussed in this course.

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.
Prerequisites: Approved undergraduate or graduate course in foundation designs within the last five years is required. 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. Applied Engineering Geology. 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.
Prerequisites: Approved undergraduate or graduate course in soil mechanics within the last five years is required. 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 662. Energy from Underground Resources. 3 credits, 3 contact hours.
Prerequisites: CE 342, or CE 341, or CE 320/ME 304, or CHEM 125, or EVSC 325, or permission of the instructor. Restrictions: Restricted to students with a STEM background. This course will provide students with fundamental and applied engineering knowledge critical for identifying, designing, and harnessing various economically valuable materials from deep underground to provide society with renewable and non-renewable energy. This course covers essential energy engineering concepts and technologies related to advancing the current and emerging underground energy resources such as oil and gas, metallic and non-metallic minerals, coal, tar sands, deep underground water, carbon transport and geo-sequestration, and hydrogen geological storage. This course will also explore the governing mechanisms controlling the transfer of fluid and mass at varying deep underground temperature and pressure conditions for safe and efficient extraction and utilization of these energy resources. Case study applications are included to show students how to apply the learned energy techniques in various engineering and science practices.

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 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. Master’s students registering for the first time in Master’s Project must take simultaneously the INTD 799 (Responsible Contact of Research) course.

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). Master’s students registering for the first time in Master’s Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

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 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 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.
Pre or Corequisite: 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.
Pre or Corequisites: 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.
Pre 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.
Pre 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 700B. Master's Project. 3 credits, 3 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. Master’s students registering for the first time in Master’s Project must take simultaneously the INTD 799 (Responsible Contact of Research) course.

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). Master's students registering for the first time in Master's Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

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 703. Biogeochemical Applications in Environmental Engineering. 3 credits, 3 contact hours.
Pre or Corequisites: ENE 663 Water Chemistry, ENE 661 Environmental Microbiology. This class will combine theoretical concepts (lectures) with laboratory and field studies to integrate the basic principles of environmental engineering, chemistry and microbiology to solve practical problems of assessment and treatment of contaminated sites. In the lectures, the students will be introduced to environmental regulations, the theoretical concepts for environmental sampling design, the procedures for analytical techniques, and traditional and cutting-edge remediation approaches. These lectures will be supplemented with peer-reviewed articles, technical reports, and operational methods. The field studies will consist in sampling collection methods, where the students will participate in a one-day sampling trip to a contaminated site to collect water, sediments, and plants samples. The students will then process the samples in the laboratory for further analysis for the contaminants of interest. Using this information, the students will prepare a Feasibility Study/Remedial Investigation (FS/RI) for their targeted site where they will evaluate three to five remediation strategies and will propose one final remediation design. The final RI/RD will be presented to the whole class in a mock Community Advisory Group (CAG) session.

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 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 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.