Civil and Environmental Engineering

Website (http://www.civ.neu.edu)

Jerome F. Hajjar, PhD, PE
CDM Smith Professor and Chair
400 Snell Engineering Center
617.373.2444
617.373.4419 (fax)

As a leader in civil and environmental engineering research and education, our mission is to prepare undergraduate and graduate engineers to excel in their chosen careers, including engineering practice, academia, infrastructure management, land-use planning and development, urban and regional planning, public sector leadership, and a wide range of other careers chosen by our diverse student body.

Having a range of teaching and research strengths, anchored by several multidisciplinary, multi-institutional centers and programs that are core to the activities of the department, our department’s strategic focus on urban engineering prepares future engineers for many of the greatest challenges of our time. Also, building on current strengths and expanding into new and vital areas in civil and environmental engineering, three overarching themes are highlighted in our department, including environmental health, civil infrastructure security, and sustainable resource engineering, all aligned with four premier departmental strengths in simulation (both computational and experimental), smart sensing, data and network science, and urban informatics.

The civil engineering and environmental engineering programs are designed to provide students with a broad education appropriate for a variety of career choices and lifelong learning. The Department of Civil and Environmental Engineering offers two academic programs leading to Bachelor of Science degrees:

- Civil engineering
- Environmental engineering

Five-year Bachelor of Science in Civil Engineering/Master of Science (PlusOne programs) are also available in the following disciplines:

- Civil engineering
- Engineering management
- Sustainable building systems

In addition, the department offers the following minors:

- Civil engineering (for non–civil engineering majors)
- Architectural engineering

By participating in our cooperative education program, our graduates will have an opportunity to explore what career objectives fit their own skills and interests. The goal of this component of our program is to offer students valuable professional experience and contacts that will help get them started in their professional career, as well as to develop career management skills. The co-op program parallels the academic program in level of responsibility and sophistication.

The department also offers significant research opportunities throughout all fields of civil and environmental engineering, including participating in research centers based in our department and college, as well as new interdisciplinary graduate and professional master’s programs.

Our mission is to prepare students to contribute to society as civil and environmental engineers who will be technically competent, creative, critical thinkers and skilled as communicators. Their educational background qualifies them to seek licensure as professional engineers and/or to pursue graduate studies.

Our students have an opportunity to obtain a broad knowledge base in science, engineering, and general studies that allows them flexibility in career development and graduate education. At the same time, our graduates should be responsible and scientifically educated citizens, prepared to contribute personally as well as professionally to an educated, democratic society.

Experience tells us that civil and environmental engineering graduates will enter almost every field imaginable. The knowledge and skills acquired—understanding science, critical thinking, effective communication, and understanding the social context, among them—form an excellent foundation for a host of careers, as well as for a fulfilling life outside the world of work. Our programs have been designed with five general electives that permit students to explore or acquire further depth in other fields of interest. Students can use these electives to earn a minor in architectural engineering, business, architectural history, music, computer science, or any number of other fields.

CIVIL ENGINEERING

Civil engineers apply their knowledge of mathematics and sciences to improve and protect the natural environment and to design and create the built environment for community living, industry, and transportation. Civil engineering encompasses several disciplines, including environmental and water resources engineering, transportation planning and engineering, structural engineering, geotechnical engineering, and construction management.

The program educational objectives are as follows:

1. The civil engineering program at Northeastern University seeks to prepare graduates to contribute to society as civil engineers and in other professions that benefit from a technical education.
2. Within a few years of graduation, many of our graduates will be working in responsible engineering positions that will qualify them to take the professional engineers (PE) licensure exam in any of the 50 United States, and they will be prepared to successfully pursue advanced study in civil engineering and other related fields.

ENVIRONMENTAL ENGINEERING

By applying their background in engineering, chemical, biological, and ecological principles, Northeastern’s environmental engineering graduates create, invent, and lead a new generation of engineers who will be able to address key challenges—including developing sustainable resource engineering solutions to environmental health needs with an understanding of institutional and legal frameworks, all related to interconnected challenges in water, energy, air pollution, and waste management—to protect and provide a better quality of life to the human race. Our program at Northeastern provides our graduates with the core skills necessary to practice environmental engineering and to work with other engineers and urban and regional planners in an interdisciplinary environment.

The program educational objectives are as follows:
1. The environmental engineering program at Northeastern University seeks to prepare graduates to contribute to society as environmental engineers and in other professions that benefit from a technical education.

2. Within a few years of graduation, many of our graduates will be working in responsible engineering positions that will qualify them to take the professional engineers (PE) licensure exam in any of the 50 United States, and they will be prepared to successfully pursue advanced study in environmental engineering and other related fields.

**Programs**

**Bachelor of Science (BSEnvE)**
- Environmental Engineering, BSEnvE (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/environmental-engineering-bsenv)

**Bachelor of Science in Civil Engineering (BSCE)**
- Civil Engineering, BSCE (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/environmental-engineering-bsce)

**Minor**
- Architectural Engineering, Minor (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/architectural-engineering-minor)
- Civil Engineering, Minor (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/civil-engineering-minor)

**Accelerated Programs**
See Accelerated Bachelor/Graduate Degree Programs (http://catalog.northeastern.edu/undergraduate/engineering/accelerated-bachelor-graduate-degree-programs/#programtext)

**Courses**

**Civil and Environmental Engineering Courses**

**CIVE 1200. How Cities Work: Experiencing Urban Infrastructure. 4 Hours.**
Introduces students to the design and operation of engineering systems that exist beneath our feet but whose operation is critical to urban dwellers using Boston as our guide. Topics include soil mechanics, structural systems, stormwater management, and waste management.

**CIVE 1990. Elective. 1-4 Hours.**
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

**CIVE 2000. Introduction to Engineering Co-op Education. 1 Hour.**
Provides students preparation for the first co-op experience. Focuses on skills that provide a basis for successful co-op engagement including expectations and requirements, an introduction to professional credentials, CV and cover letter construction, self-assessment and goal setting, interviewing, professional and co-op ethics, issues of diversity in the workplace community, academic planning and decision making, and an introduction to career portfolios.

**CIVE 2221. Statics and Strength of Materials. 4 Hours.**
Introduces solid mechanics including properties of areas and volumes (centroids axes, moments of inertia, and so on), equilibrium of particles and rigid bodies in two and three dimensions, analysis of internal forces in trusses and simple frames, shear and moment diagrams in beams, computation of stresses induced by moment, shear and torque, and mechanical properties of materials.

**CIVE 2222. Recitation for CIVE 2221. 0 Hours.**
Accompanies CIVE 2221. Covers problem solving and topics related to the course.

**CIVE 2260. Civil Engineering Materials. 4 Hours.**
Introduces the physical, mechanical, and chemical properties of materials that exist beneath our feet but whose operation is critical to urban dwellers using Boston as our guide. Offers an overview of the ways in which these properties affect the material selection process, material behavior, and the design process.

**CIVE 2261. Materials and Measurements Lab. 1 Hour.**
Involves the use of standard lab test methods and equipment to determine properties of materials common to civil engineering practice. Also introduces students to land surveying, site layout, and the measurement of distance, elevation, and direction.

**CIVE 2320. Structural Analysis 1. 4 Hours.**
Covers shear stresses in beams, combined stress analysis (bars with axial load plus shear and bending), introduction to buckling, influence lines (application to statically determinate systems), computation of deflections (statically determinate systems), and analysis of indeterminate structures using the flexibility method and moment distribution.

**CIVE 2321. Recitation for CIVE 2320. 0 Hours.**
Accompanies CIVE 2320. Covers problem solving and topics related to the course.

**CIVE 2324. Reinforced Concrete Design. 4 Hours.**
Covers the design of concrete structural elements. Explores the properties of steel and concrete. Examines behavior and design of reinforced concrete beams, one-way slab systems, footings, and short columns based on latest ACI-318.

**CIVE 2331. Fluid Mechanics. 4 Hours.**
Introduces the principles of fluid mechanics and the applications in basic hydraulic engineering systems. Topics include properties of fluids; pressure and force on surfaces and submerged bodies; continuity, momentum, and energy conservation principles; dimensional analysis and hydraulic similitude; flow in closed conduits; steady flow in pipe networks; unsteady flow in pipes; flow in open channels; hydraulic machines; and hydraulic structures. The laboratory component includes demonstrations and experiments to show the applicability of fluid mechanics and hydraulics principles.

**CIVE 2334. Environmental Engineering 1. 4 Hours.**
Focuses on protection and management of the environment. Topics include assessment of environmental quality; introduction to water and wastewater treatment technologies; air pollution control; and solid waste management.

**CIVE 2335. Environmental Engineering Chemistry. 4 Hours.**
Covers chemistry principles required for describing chemical processing of elements in natural systems, the distribution of pollutants in the environment, and chemical use in engineered treatment systems. Focuses on equilibrium thermodynamics and equilibria for acid-base, gas-water, precipitation-dissolution, metal complexation, oxidation-reduction, and sorption reactions. Discusses specific applications to pollutant reactions in surface waters, ground waters, soils, drinking water treatment, wastewater treatment, and the atmosphere.
CIVE 2340. Soil Mechanics. 4 Hours.
Studies soil classification, soil-water phase relations, water in soil, seepage, consolidation theory, and strength properties of soils.

CIVE 2341. Lab for CIVE 2340. 1 Hour.
Accompanies CIVE 2340. Introduces standard laboratory procedures for characterizing the physical, hydraulic, and mechanical properties of soils as well as data reduction and analysis methods for various test methods. Laboratory methods and determinations include moisture content, Atterberg limits, permeability, compaction, consolidation, and direct shear. Includes the use of computer-based data acquisition systems and measurement transducers.

CIVE 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CIVE 3000. Professional Issues in Engineering. 1 Hour.
Provides students with an opportunity to reflect on both academic and co-op experiences in the context of planning for the senior year and beyond. Issues include professional and ethical issues, resolving ethical conflicts, awareness of engineers as professionals in a diverse world, strengthening decision-making skills, career portfolios, and lifelong learning needs, goals, and strategies. Students reflect upon issues of diversity from their experience in the University and in their cooperative education placements. Explores the role of different work and learning styles and diverse personal characteristics on the workplace and the classroom. Professional issues include impact of the cultural context, both in the United States and around the world, on the client, government relations, and workplace.

CIVE 3425. Steel Design. 4 Hours.
Concentrates on design of steel members subject to tension, compression, bending, and combinations of loading, and design of connections, braced frames, and rigid frames. Design is based on the latest load resistance factor specifications of the American Institute for Steel Construction code. The theoretical basis of code formulas is also emphasized.

CIVE 3430. Engineering Microbiology and Ecology. 4 Hours.
Introduces the importance of microorganisms and plants to the natural and built environments, including global biogeochemical cycles, ecosystem composition and stability, and engineering applications. Seeks to provide a fundamental understanding of microorganisms (metabolisms, growth, genetics, resource requirements, and niche) and their role in the global ecosystem (element cycling, energy flows, food webs). Examines the role of plant microbes in both engineered and nature systems for beneficial environmental applications and bidirectional interactions between the natural and the built environment through a series of case studies that highlight the challenges of and strategies for engineering in the earth system context, such as microbiologically mediated infrastructure corrosion, ecological effects of nutrient pollution, bioaccumulation, green infrastructure and remediation (constructed wetlands, bioremediation), and wastewater treatment.

CIVE 3435. Environmental Pollution Fate and Transport. 4 Hours.
Provides a systematic approach to analyzing the fate and transport of pollutants within natural systems. Equilibrium modeling and reactive transport modeling are used to assess the predominant processes that control the movement and persistence of pollutants in water, soil, and air. Topics include mass transfer across multiple phases; physical, chemical, and biological transformations of substances; transport processes (diffusion, dispersion, advection, interphase mass transport); eutrophication of lakes; conventional pollutants in rivers and estuaries; groundwater contamination; and atmospheric deposition.

CIVE 3464. Probability and Engineering Economy for Civil Engineering. 4 Hours.
Introduces engineering probability and statistics, as well as engineering economic analysis for project or design evaluation. Case studies are used to illustrate the integration of these areas in the design/system analysis process. Topics in engineering probability and statistics include descriptive statistics, expected value of random variables, and hypotheses testing. Statistical process control and sampling methods are introduced. Reliability methods for the analysis and improvement of system/design performance are discussed. Also covers fundamental concepts of time value of money and economic evaluation of alternatives, including the effects of depreciation and taxes.

CIVE 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CIVE 4534. Environmental Engineering 2. 3 Hours.
Continues CIVE 2334. Concentrates on unit operations, unit processes, and related fundamental design of physical, chemical, and biological water and wastewater treatment systems, using both lectures and laboratory instruction. Topics include aeration systems, activated sludge, fixed-film biological treatment, gas transfer, reaction kinetics, reactor modeling, coagulation, flocculation, sedimentation, filtration, and subsurface disposal system design.

CIVE 4535. Lab for CIVE 4534. 1 Hour.
Accompanies CIVE 4534. Covers topics from the course through various experiments.

CIVE 4540. Resource Recovery and Waste Treatment Technologies Abroad. 4 Hours.
Examines different aspects relative to municipal and industrial solid waste, with a special focus on material recovery. Covers chemical-physical characterization of waste, source reduction and toxicity, recycling and selection of different fractions, resource and energy recovery (e.g., composting, anaerobic digestion, combustion to energy), and analysis and preliminary design of treatment disposal options. Through design projects, offers students an opportunity to apply lessons learned to the U.S. context. Taught in a study-abroad format in a European nation.

CIVE 4541. Waste Management and Policy Abroad. 4 Hours.
Explores how the country visited manages the recovery and treatment of both industrial and municipal solid waste. Emphasizes waste generated in mining and other industrial activities (e.g., refinery, military). Examines multifaceted aspects, including governance; science/engineering; and health, social, and policy. Offers students an opportunity to interact with local experts and to visit key sights. Encourages students to think about possible policy lessons for the United States. Taught abroad.

CIVE 4542. Foundation Engineering. 4 Hours.
Explores soil-bearing capacity determination, design of shallow foundations and pile foundations, and design of retaining walls and excavation support systems.

CIVE 4554. Highway Engineering. 4 Hours.
Concentrates on highway design including route selection, geometric design, foundation and pavement design, drainage design, and construction issues. Analyzes highway traffic including traffic flow fundamentals and capacity and level of service analysis for freeways and rural highways. Covers the environmental impact and public review process for highway construction. Includes project component.
CIVE 4566. Design for Sustainable Transportation: Netherlands. 4 Hours.
Examines how the design of Dutch transportation infrastructure promotes travel by foot, bicycle, and public transportation as opposed to private automobile and how it promotes urban livability and traffic safety. Topics include bicycling infrastructure planning and design; Vision Zero traffic safety principles and design treatments for safe roads, intersections, and crossings; and high-quality transit service planning and design. Through design projects, offers students an opportunity to apply lessons learned to the U.S. context. Taught in a study-abroad format in the Netherlands.

CIVE 4567. Planning and Policy for Sustainable Urban Transportation: Netherlands. 4 Hours.
Examines urban transportation planning practices and policies in the Netherlands that promote travel by bicycling, public transportation, and foot and help prevent urban mobility from degrading urban livability. Topics include land-use planning at the site, neighborhood, and regional scale; transit- and bicycle-oriented development, including both land-use and transportation infrastructure planning and policies for largescale urban expansions; and traffic-circulation planning and policies to promote safety; prevent roads from becoming barriers to walking, cycling, or transit, and to create car-free and car-lite zones. Taught in study-abroad format in the Netherlands.

CIVE 4575. Construction Management. 3 Hours.
Surveys the construction industry and tasks that must be addressed by construction management including resource allocation, construction environment, organization, contracts, funding, cash flow, productivity, conceptual and detailed cost estimating, labor relations, network planning and scheduling, construction accounting, and project control.

CIVE 4699. Special Topics in Civil Engineering. 4 Hours.
Covers special topics in civil engineering initiated by the appropriate discipline committee and approved by the department. May be repeated without limit.

CIVE 4700. Civil Engineering Research. 4 Hours.
Offers independent work for students in the University Honors Program under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

CIVE 4765. Senior Design Project—Environmental. 5 Hours.
Using teams, students design a civil engineering project that primarily involves the environmental subdiscipline. Design teams are advised by a faculty member and engineering practitioners. Lectures cover supplemental technical background specific to the project, as well as cross-disciplinary aspects of project development, value engineering, aesthetics, and constructability. Integrates project design with further development of student communications skills; students present the design to practicing engineers and interested parties such as community groups.

CIVE 4766. Senior Design Project—Geotechnical. 5 Hours.
Using teams, students design a civil engineering project that primarily involves the geotechnical subdiscipline. Design teams are advised by a faculty member and engineering practitioners. Lectures cover supplemental technical background specific to the project, as well as cross-disciplinary aspects of project development, value engineering, aesthetics, and constructability. Integrates project design with further development of student communications skills; students present the design to practicing engineers and interested parties such as community groups.

CIVE 4767. Senior Design Project—Structural. 5 Hours.
Using teams, students design a civil engineering project that primarily involves the structural subdiscipline. Design teams are advised by a faculty member and engineering practitioners. Lectures cover supplemental technical background specific to the project, as well as cross-disciplinary aspects of project development, value engineering, aesthetics, and constructability. Integrates project design with further development of student communications skills; students present the design to practicing engineers and interested parties such as community groups.

CIVE 4768. Senior Design Project—Transportation. 5 Hours.
Using teams, students design a civil engineering project that primarily involves the transportation subdiscipline. Design teams are advised by a faculty member and engineering practitioners. Lectures cover supplemental technical background specific to the project, as well as cross-disciplinary aspects of project development, value engineering, aesthetics, and constructability. Integrates project design with further development of student communications skills; students present the design to practicing engineers and interested parties such as community groups.

CIVE 4777. Climate Hazards and Resilient Cities Abroad. 4 Hours.
Focuses on the science of “global weirding”—unprecedented changes in weather caused by global warming and natural climate variability. Introduces the physical-science basis of climate, computer models of the earth system, statistical tools for the analysis of climate model, and remote sensor data. Also introduces the concept of urban resilience, focusing on preventing natural hazards from turning into catastrophic disasters in densely populated and vulnerable regions. Examines multifaceted aspects of resilience, including governance, emergency response, infrastructural, informational, social, and policy aspects. Encourages students to consider the science, engineering, and policy challenges in transforming vulnerable urban and coastal regions to climate-resilient cities and to examine how societies can learn from each other by comparing Boston with the country visited. Taught abroad.

CIVE 4778. Climate Adaptation and Policy Abroad. 4 Hours.
Explores how the country visited plans to adapt to climate change and natural hazards and how that country participates in international climate and emissions negotiations, within the context of its history and culture. Focuses on how an emerging economy adjusts to the reality of climate change/extremes and how citizens may drive decisions and policy. Incorporates topics from climate change, environmental sciences, civil and chemical engineering, remote sensing, social sciences, electrical engineering, computer science, and the management sciences. Encourages students to think about possible policy lessons for the United States. Offers students an opportunity to visit key sights. Culminates with a mock “climate change war game,” simulating an event in which international negotiators meet to formulate treaties on climate change adaptation and mitigation. Taught abroad.

CIVE 4970. Junior/Senior Honors Project 1. 4 Hours.
Focuses on in-depth project in which a student conducts research or produces a product related to the student’s major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8 credit honors project. May be repeated without limit.

CIVE 4971. Junior/Senior Honors Project 2. 4 Hours.
Focuses on second semester of in-depth project in which a student conducts research or produces a product related to the student’s major field. May be repeated without limit.

CIVE 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
CIVE 4991. Research. 4 Hours.
Offers an opportunity to conduct research under faculty supervision.

CIVE 4992. Directed Study. 1-4 Hours.
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

CIVE 4993. Independent Study. 1-4 Hours.
Offers theoretical or experimental work under individual faculty supervision. May be repeated without limit.

CIVE 4994. Internship. 4 Hours.
Offers students an opportunity for internship work. May be repeated without limit.

CIVE 4996. Experiential Education Directed Study. 4 Hours.
Draws upon the student's approved experiential activity and integrates it with study in the academic major. Restricted to those students who are using the course to fulfill their experiential education requirement. May be repeated without limit.

CIVE 5221. Construction Project Control and Organization. 2 Hours.
Overviews the organization of construction firms at the general corporate level and the project level. Covers cost, schedule, budget, and financial control of projects. Also examines the flow of information between parties to the project.

CIVE 5231. Alternative Project Delivery Systems in Construction. 2 Hours.
Offers a comprehensive overview of alternative construction project delivery systems in the public and private sectors; project life cycle including project development, schedule, cost and risk management, quality assurance/quality control, project management, and project closeout; innovative financing strategies including contractor financing, franchises, and super turnkey. Focuses on the analysis of design/bid/build execution compared to design/build and construction management systems of delivery. Examines international projects, contracts, and partnering options—for example JVs and alliances—as vehicles to ensure the meeting of project objectives. Uses case studies to identify and practice the management skills required for successful D/B project execution including effective communication, negotiations, and team building.

CIVE 5250. Organic Pollutants in the Environment. 4 Hours.
Introduces principles that govern the fate and transport of organic chemicals released to the environment. Topics include chemical structure and thermodynamic properties and how they predict physical processes that control the distribution of contaminants between the atmosphere, fresh and marine surface waters, groundwater, soils, sediments, and biota. Introduces models and methods for predicting fate and transport of organic contaminants within and between environmental media, including molecular diffusion, transport across boundaries, and box models. Explores concepts linking environmental chemistry with ecotoxicology, including bioaccumulation, food web models, and risk assessment. Uses case studies and real-world scenarios to illustrate concepts. Prereq: (a) Either CHEM 1151 or CHEM 1211 and junior or senior standing or (b) graduate standing.

CIVE 5250. Environmental Fluid Mechanics. 4 Hours.
Focuses on fundamentals of fluid mechanics, but with application to the natural and built environment based on transport and dispersion phenomena. Reviews theory necessary for an understanding of environmental fluid flows and methods of observation, including acoustic Doppler current profiles, profiling towers, and modeling, including large eddy simulation (LES).

CIVE 5261. Dynamic Modeling for Environmental Investment and Policymaking. 4 Hours.
Introduces the theory, methods, and tools of dynamic modeling for policy and investment decision making, emphasizing environmental issues. Makes use of state-of-the-art computing methods to translate theory and concepts into executable models and offers extensive hands-on modeling experience. Topics include management of discrete flows (e.g., models of traffic systems); discounting, intertemporal optimization (e.g., models of resource extraction); dynamic games (e.g., models for adaptive management); and treatment of risk, uncertainty, novelty, and complexity (e.g., for investment and policymaking).

CIVE 5270. Environmental Protection and Management. 4 Hours.
Examines public and private environmental quality management and resource protection systems. Considers regulatory issues, risk management approaches, local vs. regional impacts, long-term sustainability, and economic/financial issues. Covers selected current topics and a broad range of specific environmental issues.

CIVE 5271. Solid and Hazardous Waste Management. 4 Hours.
Introduce various aspects of integrated solid waste management system and hazardous waste management practices. Includes both engineering principles as well as socioeconomic and regulatory issues surrounding solid and hazardous waste management. Provides sufficient background to enable the student to understand, evaluate, and critique the design of and the decisions in various waste management alternatives.

CIVE 5275. Life Cycle Assessment of Materials, Products, and Infrastructure. 4 Hours.
Reviews engineering models that form the foundation of life cycle assessment (LCA), its computational structure, and relevant international standards. LCA is a widely used systems-modeling method for quantifying the environmental and health implications of a product over its entire life cycle, from manufacturing to use to disposal. This information guides design, technology decisions, and policy on topics ranging from consumer products to green buildings to the large-scale energy technologies. Students receive several hands-on training modules for popular commercial and open-source LCA software packages and have an opportunity to work examples for various products and systems. Students then carry out independent group projects for real clients in industry and government.

CIVE 5280. Remote Sensing of the Environment. 4 Hours.
Introduces remote sensing techniques, including obtaining, visualizing, and analyzing satellite data. Examines physical processes, methods, and data products used in satellite remote sensing of the Earth’s environment. Topics include active and passive remote sensing methods based on fundamentals of electromagnetic radiation, concepts used to develop data products from the remotely sensed measurements, and a suite of satellite data products to investigate current and past conditions of the Earth’s terrestrial and ocean surfaces. Uses geographic information systems (GIS) and student-developed programs to view and interpret satellite data. Knowledge of GIS, R, and Python is preferred.

CIVE 5300. Environmental Engineering Laboratory. 4 Hours.
Offers a laboratory-based course that provides students with hands-on experiences to monitor and evaluate relevant environmental processes. Introduces the theory, application, methodology, and instrumentation used in planning, sampling, and analyzing environmental contaminants in air, water, and soil. Emphasizes instrument selection and quality control, including documentation, calibration, data analysis and interpretation, and sample management. Offers students an opportunity to demonstrate the capability to select measurements strategies and sensing technologies to analyze environmental samples, conduct laboratory experiments, critically analyze experimental data, and present the experimental results.
CIVE 5321. Geoenvironmental Engineering. 4 Hours.
Covers definitions and regulations, soil formation and mineralogy, hydraulic conductivity measurements, reactive contaminant transport through fine-grained soils, landfill and liners design, and seepage barriers and cutoff walls. Introduces site characterization and remediation.

CIVE 5373. Transportation Planning and Engineering. 4 Hours.
Discusses urban transportation planning and engineering for modes other than highway. Covers travel demand forecasting for both the short and long term including impact analysis methods, simple elasticity models, and the four-step model system of trip generation, trip distribution, modal split, and network assignment. Introduces transit service analysis and design. Other topics include capacity, service, and engineering design basics for different travel modes, such as bus, airport, rail, and bicycle. Considers the environmental impact, economic evaluation, and financial impact of different modes of transportation.

CIVE 5376. Traffic Engineering. 4 Hours.
Explores traffic flow theory and measurement, capacity and level of service analysis for intersections and urban arterials, intersection layout design, intersection signal plan design for both isolated intersections and arterials, parking analysis and design, and congestion mitigation and traffic management. Offers students an opportunity to practice with standard software.

CIVE 5522. Structural Analysis 2. 4 Hours.

CIVE 5525. Prestressed Concrete Design. 4 Hours.
Introduces analysis and flexural design of prestressed concrete members, allowable stress in concrete and steel, pre- and posttensioned concrete beams, strength evaluation, and prestressed concrete bridge design. Requires one semester of undergraduate concrete design or one semester of undergraduate structural analysis.

CIVE 5536. Hydrologic Engineering. 4 Hours.
Introduces principles of engineering hydrology. Covers the hydrologic cycle; rainfall-runoff relationships; hydrologic flood routing; and ground water hydraulics. Applies these concepts to issues such as water supply and storm water management. Includes project component.

CIVE 5698. Special Topics in Civil Engineering (Nontechnical Elective). 2-4 Hours.
Offered when the need for a special topic is evident to faculty and students. Initiated by the appropriate faculty members and discipline committee and approved by the department. May not be used as a technical elective in a degree program. May be repeated up to five times for up to 12 total credits.

CIVE 5699. Special Topics in Civil Engineering. 2,4 Hours.
Offered when the need for a special topic is evident to faculty and students. Topics are initiated by appropriate faculty members and discipline committee and approved by the department. May be repeated up to five times for up to 12 total credits.

CIVE 5976. Directed Study. 1-4 Hours.
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

CIVE 5978. Independent Study. 1-4 Hours.
Offers theoretical or experimental work under individual faculty supervision. May be repeated without limit.

CIVE 5984. Research. 1-4 Hours.
Offers an opportunity to conduct research under faculty supervision. May be repeated without limit.