Civil and Environmental Engineering

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

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Overview

As a leader in research and education, the Department of Civil and Environmental Engineering at Northeastern University prepares undergraduate 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 many others.

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. Our academic programs provide future professionals with the core skills necessary to practice civil and environmental engineering and to work with other engineers in an interdisciplinary environment.

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.

Mission of the Department

Advancing innovative civil and environmental solutions for society and creating globally oriented engineering leaders by integrating experiential education and use-inspired interdisciplinary research.

Academic Programs

With a strategic focus in urban engineering, and through a range of teaching and research strengths, anchored by several multidisciplinary, multi-institutional centers and programs, our academic programs are designed to prepare future engineers to address the global, complex, and ever-evolving engineering challenges of our time by building on current department strengths and expanding into vital areas.

Three overarching themes are emphasized in our programs: environmental health, civil infrastructure security, and sustainable resource engineering. These themes are aligned with the department’s premier strengths in simulation (both computational and experimental), smart sensing, data and network science, and urban informatics and are incorporated in the undergraduate programs we offer.

Successful graduates in civil engineering and environmental engineering will have the ability to create, invent, and lead a new generation of professionals and will be able to address key challenges to protect the natural environment and to design and create the built environment for community living, industry, and society development.

Our programs have been designed with a set of 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 environmental chemistry, architectural engineering, business, architectural history, music, computer science, or any number of other fields. In the civil engineering field, our programs encompass several disciplines, including transportation planning and engineering; structural engineering; geotechnical engineering; environmental, water resources, and coastal engineering; and construction management. In the environmental engineering field, our programs include 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. For a full list of the department’s academic program offerings, please refer to the programs tab.

Other Programmatic Features

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.

Programs

Bachelor of Science in Civil Engineering (BSCE)

• Civil Engineering (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/civil-engineering-bsce/)
• Civil Engineering and Architectural Studies (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/civil-engineering-architectural-studies-bsce/)

Bachelor of Science in Environmental Engineering (BSEnVE)

• Environmental Engineering (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/environmental-engineering-bsenev/)
• Environmental Engineering and Health Science (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/environmental-engineering-health-sciences-bsenev/)
• Environmental Engineering and Landscape Architecture (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/environmental-engineering-landscape-architecture-bsenev/)

Minor

• Architectural Engineering (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/architectural-engineering-minor/)
• Civil Engineering (http://catalog.northeastern.edu/undergraduate/engineering/civil-environmental/civil-engineering-minor/)
• Environmental Chemistry (http://catalog.northeastern.edu/undergraduate/science/chemistry-chemical-biology/environmental-chemistry-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
Search CIVE Courses using FocusSearch (http://catalog.northeastern.edu/class-search/?subject=CIVE)

CIVE 1200. How Cities Work: Experiencing Urban Infrastructure. 4 Hours. Explores the networks that underpin the very existence of cities: our urban infrastructure. Designed as a grand tour of the engineering marvels that exist beneath our feet but whose operation is critical to urban dwellers, using Boston as our guide. Offers students an opportunity to study a new infrastructure system, first by learning and discussing the engineering principles behind its design and operation, and then by experiencing our local infrastructure through visits to local operation centers, city officials, and private contractors that manage and maintain them. Topics include transportation, energy, telecommunications, water and wastewater, food processing and distribution, and waste management. Explores how our infrastructure is interconnected and how this leads both to resilience and to fragility in the face of natural and anthropogenic disruptions.

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

CIVE 2221. Statics and Solid Mechanics. 4 Hours. Connects fundamentals of Newtonian physics to the stresses and deformations in solids. Introduces properties of areas and volumes (centroidal axes, moments of inertia); 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 axial force, 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. Materials for the Built Environment. 4 Hours. Introduces the physical, mechanical, and chemical properties of materials of importance to civil engineers. Offers an overview of the ways in which these properties affect the material selection process, material behavior, and the design process.

CIVE 2261. Lab for CIVE 2260. 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. 4 Hours. Connects fundamentals from CIVE 2221 to analyze stresses, strains, strength, forces, and displacements in regular structures and structural members such as trusses, beams, frames, and arches. 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 virtual work and the flexibility method. Introduces applications to sensing and monitoring of civil 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. Concrete Structure Design. 4 Hours. Presents the mechanical properties of concrete and steel reinforcement. Discusses the design of reinforced concrete structures for various loading conditions and covers the design of common reinforced concrete structural elements. Examines behavior and design of reinforced concrete beams, one-way slab systems, footings, and short columns based on latest ACI-318 code.

CIVE 2331. Fluid Mechanics and Hydraulics. 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: Principles, Technology, and Sustainability. 4 Hours. Focuses on the protection and management of the environment and the engineering methods to control environmental quality problems. Topics include assessment of environmental quality, introduction to water and wastewater treatment technologies, air pollution control technologies, solid waste management, and global atmospheric change.

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, groundwater, soils, drinking water treatment, wastewater treatment, and the atmosphere.

CIVE 2340. Geotechnical Engineering. 4 Hours. Focuses on the formation, composition, and classification of soil for engineering purposes; soil-water phase relations; water in soil, seepage; stresses in soil; consolidation theory; strength properties of soils; and the basics of geoenvironmental engineering.

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 2949. Introductory Directed Research in Civil and Environmental Engineering. 4 Hours.
Offers an opportunity to pursue project and other independent inquiry opportunities under faculty supervision for first- and second-year students. The course is initiated with a student-developed proposal, including expected learning outcomes and research products, which is approved by a faculty member in the department. Permission of instructor is required.

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

CIVE 3425. Steel Structure Design. 4 Hours.
Presents the design of steel structures for various loading conditions, including design of different types of frame structures that include steel members subjected to tension, compression, bending, and combinations of loading, and design of connections. Establishes the fundamentals of the behavior and the principles of creative design of steel structures using the latest load and resistance factor design (LRFD) specification of the American Institute for Steel Construction.

CIVE 3430. Engineering Microbiology and Ecology. 4 Hours.
Introduces the importance of microorganisms and plants to the natural and built environments and evidence-based decision making for complex systems constrained and defined by multiple metrics. 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 plants and microbes in both engineered and natural environmental systems and bidirectional interactions between the natural and the built environments. Framed around 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 3434. Water Treatment Systems Design. 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. Includes project component.

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 and Design. 4 Hours.
Focuses on subsurface field investigation, soil-bearing capacity determination, settlement estimation, design of shallow foundations and pile foundations, and design of retaining walls. Includes project component.

CIVE 4544. 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 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 large-scale 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 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 4780. Timber and Masonry Structures: Technology and Design Abroad. 4 Hours.
Examines mechanical properties of wood, stress grades, and working stresses as well as effects of strength-reducing characteristics, moisture content, and duration of loading and causes of wood deterioration in a study-abroad format in a European nation. Topics include glued-laminated timber and plywood, behavior and design of beams, beam-columns, and connections. Introduces the design of timber elements and structures. Offers students an opportunity to learn about the design of masonry elements and structures with a multitude of materials (concrete, mortar, and timber) and the design of masonry elements and structures.

CIVE 4781. Introduction to Preservation and Restoration of Historic Buildings, Technology, and Policies Abroad. 4 Hours.
Examines multifaceted aspects of building preservation in a study-abroad format in a European nation. Students, organized in groups, study either a particular building or architectural style and examine traditional and modern technologies, policies, regulations, and social aspects needed for the restoration of existing buildings with historical value. Building technologies may include energy efficiency, ventilation, and thermal comfort. Requires a report assessing the status of an existing building and proposing solutions for its preservation. Features guest speakers from Italian academia, local industry partners, and engineering professionals during technical visits and special seminars. Students participate in the selection of a special assignment topic for the final report.

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 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. Introduces models and methods for predicting fate of 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.

CIVE 5260. 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 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.
Covers the conceptual and mathematical basis of life cycle assessment (LCA), including engineering models of industrial energy use and emissions and environmental science models of fate and transport, exposure, and toxicology. LCA is a widely used systems-modeling method for quantifying the emissions and environmental/health implications of a product over its life cycle, from manufacturing to use to disposal. This guides design, technology decisions, and policy on topics ranging from consumer products to green buildings to large-scale energy technologies. Presents Monte Carlo simulation, structural path analysis, and model sensitivity analysis for the industrial network structure that underlies LCA modeling. Offers students an opportunity to receive hands-on training for open-source LCA software packages and 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 5281. Coastal Dynamics and Design. 4 Hours.
Introduces the basic theory of the forcing and response of the built and natural coastal environment, including hurricanes and extratropical storms, wind waves, astronomical tides, storm surges, currents, fluid-structure interactions, sediment transport, and morphological changes. Seeks to provide an overview of the physical processes and the functional design of coastal works, including anthropogenic and natural and nature-based features. Uses examples and case studies to illustrate the theory and the interdependence of water motion and coastal morphology. Emphasizes the challenges of extreme events and natural hazards in the coastal environment. Requires prior completion of one semester of fluid mechanics or equivalent.
CIVE 5300. Environmental Sampling and Analysis. 2 Hours.
Introduces the theory, application, methodology, and instrumentation used in planning, sampling, and analyzing the environmental contaminants in air, water, and soils. Emphasizes instrument selection and quality control, including documentation, calibration, data analysis and interpretation, and sample management.

CIVE 5301. Lab for CIVE 5300. 2 Hours.
Accompanies CIVE 5300. Covers topics from the course through various experiments. Includes a team project.

CIVE 5363. Climate Science, Engineering Adaptation, and Policy. 4 Hours.
Offers an evidence-based glimpse of what has been called a clear and present danger to mankind. Analyzes case studies from the magic of the butterfly effect in chaos theory to the deep challenges in physics, biogeochemistry, and data sciences. Covers topics from experimental design to satellite-based remote sensing, all the way to the design and operations of next-generation hydraulic infrastructures, transportation systems, smart grids, and communication networks, including the impacts on coastal or inland cities, the resilience to weather hazards, and the sustainability of water-energy-food resources. Includes policy issues and risk-informed trade-offs in renewable energy, environmental regulations, and emissions control. Graduate students are required to complete a mandatory class project.

CIVE 5373. Transportation Systems: Analysis and Planning. 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 and Sustainable Urban Street Design. 4 Hours.
Covers street and intersection design for meeting societal needs related to traffic capacity, level of service, safety, walkability, bikeability, and the quality of public space. Intersection analysis and design topics include traffic flow theory and measurement; capacity; queuing and delay for both vehicles and pedestrians; and signal timing plan design, including design for pedestrian crossings. Street design topics include street functions; speed control; street and intersection layout; bicycling facilities, including bike lanes and separated bike paths; and pedestrian facilities, including sidewalks and crossings. Offers students an opportunity to practice with standard design manuals and intersection analysis software.

CIVE 5520. Structural Systems. 4 Hours.
Covers the design of structural systems. Includes the major aspects of structural behavior and design (loads, load paths, structural system concepts, analysis, member and connection design, and structural detailing). Discusses typical structural building materials along with a brief introduction to less conventional materials. Emphasizes wood and masonry design. Also presents structural principles behind some innovative structural systems. Utilizes current professional practice with a focus on approximate hand methods of structural analysis. Requires one semester of undergraduate structural analysis.

CIVE 5522. Structural Systems Modeling. 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 and Hydraulic Design. 4 Hours.
Introduces principles of engineering hydrology. Covers the hydrologic cycle, rainfall and flood frequency analysis, rainfall intensity-duration-frequency relationships, rainfall-runoff processes, hydrologic flood routing, and culvert/channel hydraulics. Utilizes these concepts in design applications of civil infrastructure such as stormwater detention basins, drainage pipes, culverts, etc. Uses hydrologic and hydraulic modeling software such as HEC-HMS and HEC-RAS. Includes project component.

CIVE 5699. Special Topics in Civil Engineering. 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 two times for up to 12 total credits.

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.