Civil and Environmental Engineering

Chair

- A. Allen Bradley Jr.

Undergraduate majors: civil engineering (BSE); environmental engineering (BSE)

Graduate degrees: MS in civil and environmental engineering; PhD in civil and environmental engineering

Faculty: https://engineering.uiowa.edu/cee/cee-people

Website: https://engineering.uiowa.edu/cee

Civil and environmental engineering is one of the three largest fields of engineering. It traditionally has been concerned with infrastructure facilities that are both large in scale and essential to modern life. Civil and environmental engineering projects include transportation systems and their components, such as bridges, highways, public transit systems, railways, harbors, airports, and seaports; large-scale structures and office buildings that provide enclosed working and living space; and environmental and hydraulic systems that provide clean water and air, including filtration plants and distribution systems for municipal and industrial water supplies, wastewater treatment plants, dams, levees, and irrigation systems.

Growth areas of civil and environmental engineering include water sustainability, infrastructure development, construction management, computer-aided design, hazardous waste management, and engineered environmental systems. In the future, civil and environmental engineers will be called upon to design structures for the earth, prevent erosion and sedimentation of rivers, predict the effects of global climate change on the environment, provide modern and efficient transportation systems, and ensure the quality of air, surface waters, and groundwaters.

In planning and design, civil and environmental engineers work with other engineers, architects, landscape architects, planners, economists, financiers, sociologists, lawyers, and other specialists as members of the design team. Some civil and environmental engineers work in engineering offices; others may be called upon to construct or supervise outdoor projects they have designed. These field assignments, many of which are in remote and fascinating parts of the world, are particularly appealing to many civil and environmental engineers. There also is significant potential for entrepreneurial work by civil and environmental engineers as they start their own companies.

In addition to the degree programs offered by the Department of Civil and Environmental Engineering, the department also participates in two Graduate College programs: Applied Mathematical and Computational Sciences, an interdisciplinary doctoral program; and Transportation Planning, a graduate certificate program.

Certificates

Sustainable Water Development

The graduate Certificate in Sustainable Water Development trains science, technology, engineering, and mathematics (STEM) students to address future challenges of water scarcity and variability while also meeting the food and energy demands of Earth's growing population. The Department of Civil and Environmental Engineering administers the certificate program; see the Certificate in Sustainable Water Development in the catalog.

Related Certificate: Transportation Planning

The graduate Certificate in Transportation Planning focuses on the varied and complex problems of transportation and on interdisciplinary approaches to addressing them. The departments of Civil and Environmental Engineering, Industrial and Systems Engineering, Mechanical Engineering (College of Engineering), and Economics (Tippie College of Business), and the School of Planning and Public Affairs (Graduate College) participate in the program.

The certificate is coordinated by the School of Planning and Public Affairs; see the Certificate in Transportation Planning in the catalog.

Programs

Undergraduate Programs of Study

Majors

- Major in Civil Engineering (Bachelor of Science in Engineering)
- Major in Environmental Engineering (Bachelor of Science in Engineering)

Graduate Programs of Study

- Master of Science in Civil and Environmental Engineering
- Doctor of Philosophy in Civil and Environmental Engineering

Facilities

Undergraduate Teaching Laboratories

Environmental Engineering Teaching Laboratory

Located at the water plant, this laboratory is designed to provide undergraduate students hands-on experience in water laboratory testing and analysis. It serves several program-required and elective courses with a laboratory component.

Engineering Fluids Laboratories

The Engineering Fluids Laboratories comprise a trio of rooms. The Fluids Fundamentals Lab includes recently built equipment and some that has been around for decades. The Advanced Measurements Lab includes larger experimental devices, such as a wind tunnel and a towing tank. The third laboratory, the Fluids Workshop, is a space in which students can perform their experiments.

Hydraulics Laboratory

The Hydraulics Laboratory experimental facilities include flumes and pipe systems to perform experiments on open-channel and closed-conduit flows. Instruments are available

for measuring various flow quantities such as discharge, pressure, velocity, and temperature.

Computer-Aided Design (CAD) Lab

The CAD Lab contains 17 workstations, all connected to the engineering computer network, that allow students to access AutoCAD, Pro/ENGINEER, and a full complement of structural, hydraulic, transportation, and environmental software to support work on engineering design projects.

Geomechanics Laboratory

This modern 936-square-foot climate-controlled wet teaching lab features two sinks, 10 central compressed air outlets, 10 central vacuum outlets, and a fume hood. It can accommodate up to 18 students at a time. The lab is outfitted for measurements of soil grain specific gravities, soil densities, grain-size distributions, Atterberg limits, hydraulic conductivities, liquefaction, soil compressibility, time-dependent soil consolidation properties, shear strength of soils via direct shear and triaxial compression machines, and soil compaction behavior.

Structures, Mechanics, and Materials Laboratory

The Structures, Mechanics, and Materials Laboratory is a teaching lab where students conduct experiments to quantify the physical and mechanical properties of construction materials. Equipment is available to test metals, aggregates, concrete, and asphalt.

Graduate Laboratories

Structures, Mechanics, and Materials

Facilities for computations, materials testing, geotechnical experiments, and small-scale structural testing are available for research and teaching. Faculty, staff, and students in structures, mechanics, and materials (SMM) have access to the computing resources of the Engineering Technology Center and the Iowa Technology Institute (ITI). Both centers continuously update their computing facilities to maintain pace with the rapidly changing field.

A wide range of experimental facilities are available for testing structural materials such as Portland cement concrete, asphalt, metals, timber, and composites. These facilities include several loading frames (purely uniaxial, purely torsional, and axial-torsional) that are available with computer-based control and data collection systems. Facilities for creep testing, triaxial soil testing, and high-cycle fatigue testing are also available. The laboratories have a variety of ovens and other facilities for the preparation and treatment of test specimens.

Four well-equipped physical testing laboratories are dedicated to SMM teaching and research: the Civil Materials Laboratory, the Soil Mechanics Laboratory, the Plasticity Laboratory, and the Asphalt Laboratory. The Civil Materials Laboratory currently has a small-scale, single-degree-of-freedom shaker table. Faculty, staff, and students have access through ITI to a six-degree-of-freedom man-rated shaker table with a 4,000-pound payload and a 12-camera Vicon motion-capture system.

Transportation Engineering

The department's Asphalt Laboratory is equipped with a set of Superpave testing equipment and asphalt mixture performance testing equipment. The lab has a Hamburg wheel tracking device for measuring the moisture sensitivity of asphalt mixtures, asphalt foaming equipment for mix design of cold in-place recycled asphalt using foamed asphalt, and equipment for semi-circular bending and indirect tensile strength tests and volumetric analysis of asphalt mixtures. The Asphalt Laboratory is one of the department's many laboratories for testing the strength behavior of other materials.

Water and the Environment

The teaching and research functions of the department are closely connected to the research activities of IIHR—Hydroscience and Engineering. The institute houses some of the most modern research facilities in the world, including a 100-meter towing tank, a wave basin facility for ship hydrodynamics research, several flumes, an array of field instrumentation for hydrologic experiments, extensive laboratory space for hydraulic modeling, state-of-the-art instrumentation for flow measurements and visualization, and comprehensive computational facilities.

Research related to ecohydraulics and the environment takes place at the Lucille A. Carver Mississippi Riverside Environmental Research Station. IIHR—Hydroscience and Engineering operates the 250-square-foot facility, which is located on the Mississippi River near Muscatine, Iowa. The station provides engineers and biological scientists with an ideal facility in which to examine the multifaceted ecohydraulic processes of the upper Mississippi. It is equipped with water quality laboratories, research boats, and a seminar room.

The Environmental Engineering and Science Laboratories provide state-of-the-art facilities, equipment, and expertise to support both undergraduate and graduate-level instruction and research. The labs support research in contaminant fate and transport in various media (air, water, soil, plants, and microbes), drinking water disinfection and distribution, wastewater treatment, geochemical-contaminant interactions, bioremediation, and phytoremediation. They also provide resources for analytical chemistry, electrochemistry, molecular biology, microscopy, computer modeling, and simulated environments at bench- and pilot-scale levels.

The Environmental Engineering and Science Laboratories are affiliated with the university's Center for Health Effects of Environmental Contamination, the Center for Global and Regional Environmental Research, the Environmental Health Sciences Research Center, an affiliate of the National Institute of Environmental Health Sciences (NIEHS), IIHR—Hydroscience and Engineering, and the Iowa Superfund Research Program.

Courses

Civil and Environmental Engineering Courses

CEE:1010 Introduction to Careers in Environmental Engineering 0 s.h.

Past, present, and future roles of environmental engineers in society; introduction to the discipline's historical roots and early visionary leaders in sanitation engineering and public health; growth during the environmental movement, and current role of environmental engineers in modern society as stewards for clean air, water, and energy; range of career opportunities available to environmental engineering majors, particularly in the emerging role of ambassadors for sustainable development.

CEE:1030 Introduction to Earth Science 3-4 s.h.
Relationships between plate tectonics, geologic time, and the rock cycle with volcanoes and igneous, sedimentary, metamorphic rocks; fossils; radioactive isotopes; landscape evolution; mountain building; natural resources; their impacts on civilization. GE: Natural Sciences with Lab; Natural Sciences without Lab. Same as SEES:1030.

CEE:1031 Introduction to Earth Science Laboratory 1 s.h.
Laboratory component of SEES:1030. Requirements: completion of 3 s.h. in SEES:1030 or CEE:1030. GE: Natural Sciences Lab only. Same as SEES:1031.

CEE:2010 Civil and Environmental Engineering Professional Practice and Ethics 1 s.h.
Introduction to the Civil and Environmental Engineering department, its curriculum, and the profession; explore the fields of civil and environmental engineering and provide a primer on the steps necessary to become a licensed professional engineer; introduce professional ethics, engineering work products, and project lifecycle.

CEE:2015 Civil Engineering Tools 2 s.h.
Tools and methods used in civil engineering career: AutoCAD, programming, project estimating, heavy equipment productivity estimation, and earthwork estimation.

CEE:2050 Severe and Unusual Weather 3 s.h.
Basic weather concepts behind severe weather phenomena and essential safety information; how weather events cause billions of dollars in damage and thousands of casualties; winter storms can impact half of the nation, paralyzing the transportation network with icy roads and wind driven snow; tornadoes can strike within minutes tearing apart homes; hurricanes can destroy entire communities with strong winds, heavy rain, and deadly storm surge; how understanding severe weather and knowing what to do before, during, and after an event can significantly reduce injury, deaths, and property damage. Same as CBE:2050.

CEE:2240 Drafting and Modeling With AutoCAD and Rhino 3 s.h.
Learn to expertly navigate AutoCAD and Rhino software to produce precise plans, elevations, and sections for various objects and interior spaces. Develop proficiency in creating and manipulating geometric forms. Explore the intricacies of texture mapping, background settings, and lighting techniques to enhance the realism of models. Master the use of cameras and viewpoints to create compelling visualizations and walkthroughs. Delve into basic animation principles to bring dynamic elements to designs. This comprehensive experience equips students with the technical skills and creative tools needed to excel in the field of digital design and modeling. Prerequisites: ARTS:1510 and ARTS:1520 and (CERM:2010 or DSGN:2500 or DRAW:2310 or INTM:2710 or MTLS:2910 or PHTO:2600 or PNTG:2410 or PRNT:2610 or SCLP:2810 or TDSN:2210). Same as TDSN:2240.

CEE:3001 Leadership Skills for Engineers 1 s.h.
Survey of leadership ideas and principles as applied to situations commonly encountered in civil engineering practice, especially as they relate to challenges that beginning engineers face; speakers in selected engineering professions provide context and examples; exercises on leadership principles. Requirements: junior standing in civil and environmental engineering.

CEE:3002 Technical Communication in Civil and Environmental Engineering 1 s.h.
Develop communication skills through data and oral presentations; demonstrate an ability to acquire data and new knowledge from reliable sources; prepare high-quality graphs for presentations. Requirements: sophomore standing.

CEE:3003 Project Management Skills 1 s.h.
Review and extension of civil and environmental engineering project management skills in preparation for capstone senior design course; project scheduling, cost estimating, contract types, construction phasing; review for Fundamentals of Engineering Exam (FE) and practice tests in four subdisciplinary areas. Requirements: senior standing.

CEE:3142 Quality Control 3 s.h.
Basic techniques of statistical quality control; application of control charts for process control variables; design of inspection plans and industrial experimentation; modern management aspects of quality assurance systems. Offered fall semesters. Prerequisites: STAT:2020 or BAIS:9100 or (STAT:3100 and STAT:3101 and STAT:3200). Same as ISE:3600, STAT:3620.

CEE:3155 Principles of Environmental Engineering 4 s.h.
Water supply and treatment processes; wastewater treatment processes; processes for air pollution control, groundwater remediation; solid and hazardous waste management. Prerequisites: CHEM:1110.

CEE:3328 Fluvial Geomorphology 3 s.h.
Hydrologic principles, stream channel processes, and fluvial geomorphology within drainage basin systems; spatial and temporal variations in water distribution, analysis of hydrological data, flow mechanisms, sediment transport, forecasting procedures, hydrograph construction, modeling. Requirements: SEES:3020 or another 3000-level geology or hydraulics course. Same as SEES:3380.

CEE:3371 Principles of Hydraulics and Hydrology 3 s.h.
Hydraulics of pressure conduits and open channels, dimensional analysis, flow measurements, hydraulic machinery, laboratory. Prerequisites: ENGR:2510.

CEE:3430 Water Treatment 4 s.h.
Physical, chemical, and biological processes and operations to remove and treat chemical and pathogenic pollutants and protect human and environmental health; relevant to drinking water, municipal wastewater, water reuse, stormwater, industrial process water, agricultural wastewater; modern technologies and appropriate designs for the developing world; theory and applications; hands-on laboratory. Prerequisites: CEE:3155 and ENGR:2510.

CEE:3530 Geomechanics 4 s.h.
Identification and classification of earth materials; hydraulic and mechanical properties of soils; soil improvement; laboratory testing. Prerequisites: ENGR:2750.

CEE:3533 Principles of Structural Engineering 4 s.h.
Fundamental principles of structural analysis applied to statically determinate and indeterminate structures, continuous beams, trusses, and frames; external and internal equilibrium, compatibility of deformation, influence lines, virtual work; parallel use of classical and matrix formulation; slope deflection, flexibility and stiffness methods; use of computers. Prerequisites: ENGR:2750.

CEE:3586 Civil Engineering Materials 3 s.h.
Structure, strength and failure, durability, deformation, practice, and processing for primary construction materials systems, including steel, aluminum, concrete, asphalt, fiber-reinforced composites, masonry, timber. Prerequisites: ENGR:2750.

CEE:3763 Principles of Transportation Engineering 3 s.h.
History of transportation modes, new transport technologies, traffic operations and control, economic evaluation of transport alternatives, transportation planning, roadway design and construction, route location, preventive maintenance strategies. Requirements: sophomore standing.

CEE:3783 Surveying and Remote Sensing 3 s.h.
Engineering surveying measurements, methods, computations. Prerequisites: ENGR:1100.

CEE:3790 Resilient Infrastructure and Emergency Response 3 s.h.
Concepts of resilient cities with specific emphasis on role of infrastructure and built environment; risk analysis, hazard mitigation and emergency response to various threats; resiliency through good design.

CEE:3996 Civil and Environmental Engineering: Engineering Project 1 s.h.
Support for student learning associated with an engineering project; students work as a team to design and fabricate a product; student projects are often associated with a contest or competitions (e.g., steel bridge, concrete canoe).

CEE:3997 Engineering Service Project 1-3 s.h.
Provides support of student learning associated with a variety of international engineering service projects facilitated by the Department of Civil and Environmental Engineering; service projects are usually designed and built as part of an Engineers Without Borders USA and/or a Bridges to Prosperity (Continental Crossings) approved program; active involvement by students in these organizations required.

CEE:3998 Individual Investigations: Civil Engineering arr.
Individual projects for civil engineering undergraduate students: laboratory study, engineering design project, analysis and simulation of an engineering system, computer software development, research.

CEE:4102 Groundwater 3 s.h.
Groundwater quality and quantity; Darcy's Law, 2D flow equation, unsaturated zone, contaminant transport, redox reactions, drinking water quality, bioremediation; laboratories in permeameter testing, porous media grain size analysis, pump testing, monitoring well installation.

CEE:4104 Groundwater Modeling 3 s.h.
Groundwater flow and contaminant transport modeling; numerical methods, applications of groundwater modeling to water supply, groundwater resources evaluation, remediation design using software; GMS (MODFLOW, MODPATH, and MT3D). Prerequisites: MATH:1860 and SEES:4630. Same as SEES:4660.

CEE:4107 Sustainable Systems 3 s.h.
New and emerging concepts in sustainable systems design and assessment. Same as CBE:4410.

CEE:4118 Statistical Methods in Water and the Environment 3 s.h.
Basic methods required for data analysis and interpretation of processes related to water and the environment; emphasis on formulating questions, choosing appropriate statistical tools for a given problem, drawing appropriate conclusions from analyses; concepts related to statistical inference and common probabilistic models, linear regression, non-parametric statistics; how to perform these analyses using R programming language; introduction to statistical methods through use of hands-on analyses with real data. Prerequisites: STAT:2020 and MATH:2560.

CEE:4119 Hydrology 3 s.h.
Overview of fundamental processes in water cycle, including precipitation, evaporation, infiltration, and runoff; quantitative approaches for predicting streamflow and design discharges; applications to flood hazard assessment and stormwater management. Prerequisites: ENGR:2510.

CEE:4135 Health Monitoring of Structural and Mechanical Systems 3 s.h.
Measurements, structural modeling, structural analysis, stiffness method, trusses and frames, structural testing, modal analysis. Prerequisites: ENGR:2750. Same as BME:4135, ME:4235.

CEE:4150 Environmental Chemistry 3 s.h.
Principles of general, physical, organic chemistry applied in water and air systems; emphasis on qualitative and quantitative understanding of chemical kinetics and equilibrium; acid-base reactions, complex formation, precipitation, dissolution, and oxidation-reduction reactions; organic nomenclature. Prerequisites: CHEM:1120. Same as CBE:4420.

CEE:4157 Environmental Engineering Design 3 s.h.
Application of physical, chemical, and biological operations and processes to the design of water and wastewater treatment systems; applications in solid and hazardous waste treatment. Prerequisites: CEE:3155.

CEE:4158 Solid and Hazardous Wastes 3 s.h.
Sources, characteristics, collection, disposal of solid and hazardous wastes; environmental impacts of hazardous waste management; resource recovery systems. Requirements: for OEH:4920—OEH:4240. Same as OEH:4920.

CEE:4159 Air Pollution Control Technology 3 s.h.
Sources, environmental and health impacts, regulations, modeling of air pollution; processes and alternative strategies for control; global climate considerations. Same as CBE:4459, IGPI:4159.

CEE:4160 Introduction to Bridge Engineering 3 s.h.
Bridge engineering and design; history of the bridge; factors that affect bridge design; bridges according to use (e.g., road, rail, pedestrian and bicycle) and type (e.g., suspension, cable stay, truss); how sustainability concepts may impact bridge design; substantial design exercise. Prerequisites: CEE:3533.

CEE:4162 Structural Systems for Buildings 3 s.h.
Detailed analysis and design of gravity and lateral force resisting systems for buildings; roof, floor, and bearing wall gravity systems; steel braced frames, steel and concrete moment frames, and masonry and timber shear walls lateral systems; introduction to tall building structures. Prerequisites: CEE:3533.

CEE:4164 Design of Wood Structures 3 s.h.
Framing layout and analysis of wood frame structures for gravity and lateral loads; design of structural members for bending, axial load, and shear, including joists, beams, columns, engineered lumber, bearing walls, shear walls, and diaphragms; introduction to connection design. Prerequisites: CEE:3533.

CEE:4176 Transportation Research Methods and Analysis 3 s.h.
Methods for measuring current and future transportation demand based on changes in population, preferences, built environment, and changing policy objectives; survey design and analysis; basics of travel demand modeling. Same as URP:4262.

CEE:4180 Fundamentals of Atmospheric Science 3 s.h.
Review of fundamental principles in atmospheric sciences needed for study of interdisciplinary topics involving the Earth's atmosphere; understanding weather and climate processes to address problems in engineering; hydrometeorology of rainfall and its measurement by remote sensing; impact of climate anomalies and climate change on water resources; exchange of water, energy, and chemicals at the land-atmosphere boundary; forecasting of atmospheric chemistry and air quality. Prerequisites: ENGR:2510.

CEE:4317 Remote Sensing 3 s.h.
Fundamentals of electromagnetic waves, atmospheric radiative transfer, passive remote sensing, weather radar, hydrologic application of remote sensing.

CEE:4370 Open Channel Flow and Sediment Transport 3 s.h.
In-depth analysis of governing flow equations; steady uniform flow in channels of different resistance and cross section; flow control sections; specific energy considerations; analysis and computation of gradually varied profiles and spatially varied flow effected by lateral outflow and inflow; unsteady flow; flood routing. Prerequisites: CEE:3371.

CEE:4371 Water Resources Engineering 3 s.h.
Planning and economics of varied water resources projects; stochastic basis for design; flood damage mitigation, reservoirs, river morphology, economic analysis of water projects, urban water requirements, water supply, hydroelectric power systems, river navigation; contemporary civil-engineering problems and issues associated with water infrastructure development. Corequisites: CEE:3371.

CEE:4374 Water Resource Design 3 s.h.
Prerequisites to storm water management systems design, including design flows and rates; analysis and design of storm sewers, detention basins, street and highway drainage facilities, culverts, dams, spillways, measures for energy dissipation; review of wastewater transfer systems and design. Prerequisites: CEE:3371.

CEE:4385 Water Scarcity in Rural India 3 s.h.
Scientific, engineering, economic, and social aspects contributing to water scarcity in rural India; experiential learning using instruments and analysis of water enhancement projects.

CEE:4506 Design of Concrete Structures 3 s.h.
Fundamental analysis and design of reinforced concrete members and structures, flexure, shear, bond, continuity, beams, one-way slab system; columns. Prerequisites: CEE:3533.

CEE:4511 Scientific Computing and Machine Learning 3 s.h.
Numerical methods in scientific computing; root problems and optimization; linear algebraic equations; eigenvalue problems; numerical differentiation and integration; interpolation and curve-fitting; initial value and boundary value problems; machine learning in regression, classification, and clustering problems; Python programming and packages. Prerequisites: MATH:2560. Same as ME:4111.

CEE:4512 Engineering Design Optimization 3 s.h.
Engineering design projects involving modeling, formulation, and analysis using optimization concepts and principles; linear and nonlinear models, optimality conditions, numerical methods. Prerequisites: ENGR:2110 and MATH:2550. Requirements: junior standing. Same as ME:4112.

CEE:4515 Computer-Aided Engineering 3 s.h.
Computational engineering modeling and simulation, geometric modeling, grid generation, finite-element and finite-volume methods, uncertainty analysis, optimization, engineering applications. Prerequisites: ENGR:2750. Corequisites: ME:3052. Same as ME:4110.

CEE:4532 Fundamentals of Vibrations 3 s.h.
Vibration of linear discrete and continuous mechanical and structural systems; harmonic, periodic, and arbitrary excitation; modal analysis; applications. Prerequisites: ENGR:2750. Same as ME:4153.

CEE:4533 Finite Element I 3 s.h.
One- and two-dimensional boundary value problems; heat flow, fluid flow, torsion of bars; trusses and frames; isoparametric mapping; higher order elements; elasticity problems; use of commercial software. Prerequisites: ENGR:2750. Same as IGPI:4115.

CEE:4535 Design of Steel Structures 3 s.h.
Concepts and procedures in steel design; LRFD (load and resistance factor design) methodology for beams/columns; analysis and design of indeterminate structures. Prerequisites: CEE:3533.

CEE:4539 Foundations of Structures 3 s.h.
Application of soil mechanics to analysis of structural foundations; slope stability analysis; bearing capacity and settlement of shallow and deep foundations; retaining structures, braced cuts, reinforced earth structures; usage of computational models; subsurface exploration methods. Prerequisites: CEE:3530.

CEE:4560 Pavement Engineering 3 s.h.
Fundamental design principles; characterization and testing of asphalt and concrete paving materials; stresses and stain development within pavement structure; basic principles of mechanistic-empirical pavement design procedures. Prerequisites: CEE:3763.

CEE:4730 Transportation Infrastructure Construction and Management 3 s.h.
Analytical methods for developing transportation infrastructure construction and management systems; e-construction, transportation infrastructure condition evaluation, performance modeling, maintenance and rehabilitation optimization, asset management, development of transportation infrastructure construction and management system; application of information technology and mobile computing to solving transportation infrastructure construction and management problems. Prerequisites: CEE:3763.

CEE:4762 Design of Transportation Systems 3 s.h.
Overview of different modes within transportation systems; concepts of sustainability and livability in transportation system design; derivation of standards for geometric design of highways; roundabout design; cross-sectional and longitudinal geometric design of highways. Prerequisites: CEE:3763.

CEE:4763 Traffic Engineering 3 s.h.
Design of traffic control devices; evaluation and analysis of intersections and transportation networks using appropriate computer software. Prerequisites: CEE:3763.

CEE:4850 Project Design and Management in Civil Engineering 3 s.h.
Design of civil engineering systems, individual and team design projects oriented toward the solution of local problems, project management, construction management, contracts, budgeting, bidding. Corequisites: CEE:3003. Requirements: final semester.

CEE:5083 Introduction to Comp Flow in Pipes and Channels 3 s.h.
General review of numerical methods in hydraulics (finite-difference, finite-element, and method of characteristics); stability and accuracy of numerical schemes; steady free surface flows; flow transients in pipelines and channels.

CEE:5095 Career Paths in Sustainable Water Development 0 s.h.
Introduction to different career paths in the food, energy, and water (FEW) sector; speakers from a variety of different careers—including researchers, professors, entrepreneurs, consultants, and civic, professional, and global engineers—discuss their own career paths as well as current opportunities in their fields; students prepare individual development plans that identify their preferred career (i.e., training) path, a plan of study (i.e., path coursework), mentors, and their preferred research area. Requirements: graduate standing in sustainable water development program.

CEE:5096 Water, Energy, and Food Nexus Seminar 0 s.h.
Invited presentations on research, policy, economics, and social drivers of water, energy, and food in the 21st century.

CEE:5097 Coaching Seminar on Communicating Water Science 0 s.h.
Presentation of student research on water, energy, and food in the 21st century; students receive live, immediate feedback from their peers and faculty coaches on best practices to improve their oral communication skills.

CEE:5098 Graduate Seminar in Structures, Materials, Mechanics, and Transportation 0 s.h.
Presentation and discussion of recent advances and research in structures, mechanics, materials, and transportation engineering by guest lecturers, faculty, and students. Requirements: graduate standing.

CEE:5099 Civil and Environmental Engineering Graduate Seminar 0 s.h.
Presentation and discussion of current topics, case studies, and research in civil and environmental engineering by students, faculty, and invited speakers.

CEE:5110 Managing and Sharing Your Research Data 1 s.h.
Overview of essential practices in managing the data you collect and generate during research. Topics include file organization; documenting your work and lab notebooks; optimizing spreadsheet data and cleanup tools; reproducibility; funder and publisher requirements; and conclude with how and where to share and publish data, from choosing a repository to creating a data record, including licensing, ownership, preservation of access, reuse, and citation. Applicable for any student currently doing research, or planning to do so. Same as OEH:5110.

CEE:5115 Atmospheric Chemistry and Physics 3 s.h.
Principal chemical and physical processes affecting atmospheric trace gas and pollutant cycles; emphasis on atmospheric photochemistry, aerosol science, major sources, and removal processes. Corequisites: CBE:3120. Same as CBE:5425.

CEE:5137 Composite Materials 3 s.h.
Mechanical behavior of composite materials and their engineering applications; composite constituents (fibers, particles, matrices) and their properties and behavior; macromechanical behavior of composite laminae; micromechanical predictions of composite overall properties; classical lamination theory; composite beams and plates. Prerequisites: ENGR:2750. Same as ME:5167.

CEE:5151 Building Future Leaders in Sustainable Development 3 s.h.
Focus on competencies needed to translate training and research into action for social good; topics include ethics, cultural competency, collaboration and team science, use-inspired design, and engagement. Same as SDG:5100.

CEE:5156 Physical and Chemical Environmental Processes 3 s.h.
Theory of physical and chemical operations and processes in water and wastewater treatment, including fundamental aspects of process dynamics; lectures, laboratory. Prerequisites: CEE:4150. Corequisites: CEE:3155.

CEE:5179 Continuum Mechanics arr.
Mechanics of continuous media; kinematics of deformation, concepts of stress and strain; conservation laws of mass, momentum and energy; constitutive theories; boundary and initial value problems. Prerequisites: ENGR:2750 or ENGR:2510. Same as ME:5179.

CEE:5225 Communicating Data Through Stories 3 s.h.
How to communicate science effectively and responsively with multiple audiences from peers and professors to potential employers, policymakers, and the lay public; focus on speaking about science clearly and vividly in ways that can engage varied audiences, especially those outside the student's own field; connecting and finding common ground with an audience, defining goals, identifying main points, speaking without jargon, explaining meaning and context, using storytelling techniques and multimedia elements. Same as GRAD:5225, SDG:5225.

CEE:5236 Optimization of Structural Systems 3 s.h.
Advanced topics; optimization of structural topology, shape, and material; finite dimensional dynamic response optimization, sensitivity analysis, distributed parameter systems; projects. Same as BME:5720.

CEE:5310 Informatics for Sustainable Systems 3 s.h.
Introduction to fundamental and advanced environmental informatics concepts and procedures including automated data collection, data management, data transformations, and processing to support modeling and analysis; scientific visualization of environmental data to support management of food, energy, and water (FEW) resources; sustainability in FEW systems. Same as IGPI:5311, URP:5310.

CEE:5350 Watershed Hydrology and Ecosystem Processes 3 s.h.
Introduction to hydrologic and ecosystem processes within a watershed; description of water, energy, and nutrient cycling in watersheds; focus on hydrologic and water-quality issues in agricultural Midwest; watershed modeling techniques, ecosystem goods and services, and selected case studies in watershed and ecosystem management problems. Requirements: graduate standing.

CEE:5355 Advanced Hydrology 3 s.h.
Expanding on core principles of hydraulics and hydrology, explore advanced distributed hydrologic modeling techniques used in early warning systems. Topics include probabilistic forecasting, spatial forecast verification, data assimilation, and data-driven simulation. Emphasis is placed on scientific computing using C++, Python, R, and MATLAB for practical learning. Prerequisites: CEE:3371.

CEE:5369 Intermediate Mechanics of Fluids 3 s.h.
Basic concepts and definitions; pressure distribution in a fluid; governing equations and boundary conditions; integral and differential analysis; dimensional analysis and similarity; experimental analysis; laminar and turbulent internal and external flows; potential flows; engineering applications. Prerequisites: ENGR:2510. Same as ME:5160.

CEE:5372 Experimental Methods in Fluid Mechanics and Heat Transfer 3 s.h.
Hands-on experience in methodology of conducting experiments in fluid mechanics and heat transfer from design to data acquisition and processing; essential theoretical elements, experimental methodologies, data acquisition systems, uncertainty analysis; wide variety of instruments for fundamental and applied experimentation; work in small groups; design, implement, test, and report an experiment in area of interest. Same as ME:5162.

CEE:5380 Fluid Flows in Environmental Systems 3 s.h.
Introduction to environmental fluid flows and transport processes with focus on application and developing a language of environmental fluid mechanics; topics include physical and mathematical description of conservation and transport laws, statistical techniques for analyzing environmental flow data, scaling and similarity, stratification, turbulent flux measurement and modeling, environmental boundary conditions; application to surface waters and the planetary boundary layer; applied project involving collection and analysis of environmental flow data.

CEE:5390 PCBs in the Environment 3 s.h.
Polychlorinated biphenyls (PCBs) as potent carcinogens and linked to metabolic syndrome, autism, learning disabilities, hearing loss, and neurological disorders; how these compounds become to be such ubiquitous environmental pollutants; what the impact of their presence is; how sites are remediated and exposures reduced; in-depth examination through literature review, laboratory experiments, computational modeling, final written reports, and presentations. Recommendations: laboratory experience.

CEE:5410 Politics and Economics of the Food, Energy, Water Nexus 3 s.h.
Focus on the relationships between food, energy, and water resources; current and future political and economic frameworks that shape the food, energy, and water nexus.

CEE:5417 Physical Meteorology and Atmospheric Radiative Transfer 3 s.h.
Physical processes for weather and climate including radiative transfer, cloud and precipitation formation, and atmospheric electricity; theory of scattering by atmospheric particles (e.g., clouds, aerosols, molecules), atmospheric radiative transfer equations, and numerical techniques and tools to solve these equations. Requirements: senior or graduate standing. Same as CBE:5417, IGPI:5417.

CEE:5440 Foundations of Environmental Chemistry and Microbiology 3 s.h.
Investigation of chemical and biological processes at the food-energy-water nexus; example topic areas include biogeochemical cycling of nutrients, biomass conversion, resource recovery from wastewater, removing pollutants from drinking water sources, water reuse, engineered natural treatment systems, pollutant transformation and control, treatment of process waters. Requirements: undergraduate senior standing or graduate standing.

CEE:5460 Water Quality and Flow 3 s.h.
Laboratory and field experiments to promote student learning of flow-dependent movement and associated environmental transformation of surface water and groundwater pollutants; exploration of water quality and flow fundamentals needed to design and numerically model treatment reactors for small-community wastewater, urban storm water, and agricultural runoff; emphasis on engineered solutions that couple water quality and flow considerations as potential mitigations for adverse effects on natural water cycle caused by floods and other natural and human-influenced phenomena.

CEE:5513 Mathematical Methods in Engineering 3 s.h.
Linear ordinary differential equations, series solutions of differential equations, special functions, Laplace transforms, Fourier series, matrices, linear systems, eigenvalue problems, second-order partial differential equations. Prerequisites: MATH:2550 and MATH:2560. Same as CBE:5140, ME:5113.

CEE:5540 Intermediate Mechanics of Deformable Bodies 3 s.h.
Application of equilibrium analyses, strain-displacement relations, and constitutive relationships to practical structural systems and elementary plane elasticity problems. Prerequisites: ENGR:2750. Same as ME:5150.

CEE:5549 Fracture Mechanics 3 s.h.
Three-dimensional stress states, definition and criteria for failure, nominal and local yield phenomena, linear elastic and elastic plastic fracture mechanics, plane stress and plane strain fracture toughness, J-Integral, crack opening displacement, environmental assisted cracking, fatigue crack growth, fail safe, and damage tolerant design. Prerequisites: ENGR:2750. Corequisites: ME:3052. Same as ME:5159.

CEE:5678 Application Simulation to Transportation 3 s.h.
Transportation system management and traffic engineering; application of real-time simulation and visualization. Prerequisites: CEE:3763 or CEE:4763. Same as URP:5678.

CEE:5875 Perspectives in Biotechnology 1 s.h.
Topics related to careers in biotechnology with an emphasis on preparing graduate students for careers outside of academia; discussions led by a series of guest speakers from leading biotech industries; understanding the societal impact of basic research; participation in round-table discussions; and presentation of student research findings. Requirements: graduate standing and good academic standing in a participating department supported by the Predoctoral Training Program in Biotechnology. Same as BMB:5875, CBE:5875, CHEM:5875, MICR:5875, PHAR:5875.

CEE:5990 Structural Engineering Practicum A 2 s.h.
Students select a design project and develop two or more alternative design concepts in consultation with a three-member advisory committee consisting of at least one faculty member and one design professional; entire design process documented in a written report. Prerequisites: CEE:4506 and CEE:4535.

CEE:5991 Structural Engineering Practicum B 1 s.h.
Detailed design development of one of the concepts developed in CEE:5990; students perform detailed design calculations using applicable structural analysis and design software, produce professional quality structural plans including connection details, and defend design to a three-member advisory committee. Prerequisites: CEE:5990.

CEE:5998 Individual Investigations: Civil and Environmental Engineering arr.
Individual projects for civil and environmental engineering graduate students: laboratory study, engineering design project, analysis and simulation of an engineering system, computer software development, research. Requirements: graduate standing.

CEE:5999 Research: Civil and Environmental Engineering MS Thesis arr.
Experimental and/or analytical investigation of an approved topic for partial fulfillment of requirements for the MS with thesis in civil and environmental engineering. Requirements: graduate standing.

CEE:6225 Communicating Science 3 s.h.
Writing and speaking about environmental engineering and science research; key principles of writing with clarity and cohesion, and practice applying these principles on a piece of research writing that students are currently working on; review best practices for presenting research to peers and at conferences; students are required to share their work with peers through writing and presentations. Recommendations: graduate standing in earth and environmental sciences; MS students must be thesis option.

CEE:6250 Environmental Biotechnology 3 s.h.
Environmental biotechnology utilizes microorganisms to improve sustainability of human society; basic concepts and quantitative tools needed for microbiological processes to behave in ways that are understandable, predictable, and unified; application of these fundamental principles to a variety of modern applications. Prerequisites: CEE:5440.

CEE:6253 Environmental Organic Chemistry 3 s.h.
Environmental factors that govern processes that determine fate of organic chemicals in natural and engineered systems; knowledge of chemical fate applied toward quantitatively assessing environmental behavior of organic chemicals; holistic view on physical-chemical properties of organic compounds, including aspects of gas-solid partitioning, bioaccumulation, and transformations in the atmosphere.

CEE:6255 Environmental Biotechnology and Bioremediation 3 s.h.
Concepts in molecular microbial ecology and bioremediation; microbial diversity and genetics, evolution of biodegradation pathways, application of quantitative PCR, high-throughput amplicon and metagenomic and transcriptomic sequencing, proteomics, stable isotopes; bioremediation research and practice.

CEE:6299 Advanced Topics in Water and the Environment 1-3 s.h.
Advanced topics or areas of study not formally offered in other civil and environmental courses; topics include environmental engineering and science, hydraulics, hydrology, water resources, and sustainable water development.

CEE:6310 Analytical Methods in Mechanical Systems 3 s.h.
Vector and function spaces; functionals and operators in Hilbert spaces; calculus of variations and functional analysis with application to mechanics; Ritz and Galerkin methods. Prerequisites: ME:5113. Same as ME:6214.

CEE:6376 Viscous Flow 3 s.h.
Equations of viscous flow; classical analytical and numerical solutions; flow regimes and approximations; laminar boundary layers—equations, solution methods, applications; stability theory and transition; incompressible turbulent flow—mean-flow and Reynolds-stress equations, modeling, turbulent boundary layers and free shear flows. Requirements: for ME:6260—ME:5160; for CEE:6376—CEE:5369. Same as ME:6260.

CEE:6520 Watershed Sedimentation 3 s.h.
Exploration of rich and complex field of sediment transport, geomorphology, and contaminant transport; associated physical, chemical, and biological processes with associated mathematical modeling; investigation of current topics not covered elsewhere, including physical processes affecting stability/mobility, transport, and fate of soil/sediments; lack of general understanding in development of fine-scale sedimentary structure in different systems, particularly contamination and contamination release; suspension effects on turbulent flows. Prerequisites: CEE:4370.

CEE:6532 Finite Element II 3 s.h.
Computer implementation; plate and shell elements; mixed and hybrid formulations; nonlinear analysis; recent development; introduction to boundary element method. Prerequisites: CEE:4533. Same as IGPI:6216, ME:6215.

CEE:6599 Advanced Topics in Infrastructure Systems 1-3 s.h.
Advanced topics or areas of study not formally offered in other structures and transportation courses; topics may include one or more areas (e.g., structural dynamics, advanced structural systems, earthquake engineering, sustainable systems).

CEE:7250 Advanced Fracture Mechanics 3 s.h.
Fracture of modern engineering materials; linear-elastic fracture; computational methods; functionally graded materials; elastic-plastic fracture; multiscale fracture and fatigue crack initiation. Prerequisites: ME:5113 and (ME:5159 or CEE:4533). Same as ME:7250.

CEE:7999 Research: Civil and Environmental Engineering PhD Dissertation arr.
Experimental and/or analytical investigation of an approved topic for partial fulfillment of requirements for the PhD in civil and environmental engineering.