

CEE Course Descriptions

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CEE Undergraduate Courses

12-050 Study Abroad

12-051 Study Abroad

Technology and the Environment

Technical elective for undergraduate, non-engineering majors. Overview of major environmental issues and concerns associated with modern technology. Topics in the course include automobiles and associated air emissions and fuel consumption, information technology and electricity usage, electricity generation and alternative sources to reduce air emissions and wastes, CFCs and their influence on the ozone layer, and various issues related to land use patterns such as agriculture and infrastructure. Methods for using technology to improve environmental conditions also discussed. Within this framework the course aims to build fundamental problem solving skills, basic familiarity with engineering calculations, and writing proficiency. The overall purpose is to instill an appreciation of the complexity of issues and viewpoints surrounding technology development and associated environmental impacts. 9 units. Offered: Spring.

12-100 Introduction to Civil and Environmental Engineering

Presentation of selected topics in the discipline with an emphasis on fundamentals. The course includes treatment of topics in mechanics and provides an exposure to environmental engineering. Problem-solving exercises within the course apply these concepts to integrate the steps of analysis, synthesis, and evaluation through individual and group projects that require attention to a broad range of issues. The course also exposes the students to issues related to engineering practice such as scheduling, evaluating risk, and making ethical decisions. In addition to regular lectures and project exercises, the course includes guest speakers, field trips, and class demonstrations. 3 hrs., rec., 1 hr.lab. 12 units. Offered: Fall and Spring.
Co-requisites: 21-115, 21-116, 33-106.

12-235 Statics

Introduction to vector mechanics; equivalent systems of forces; equilibrium of rigid bodies; free body diagram; distributed forces, hydrostatic forces, effective forces, centroids; applications to simple statically determinate trusses, beams, frames, cables and other physical systems; friction. 3 hrs. rec. 9 units. Offered: Spring.
Co-requisites: 12-100, 21-117, 21-118, 33-106.

12-351 Introduction to Environmental Engineering

Provides a scientific and engineering basis for understanding environmental issues and problems. Introduces material and energy balances for tracking substances in the atmosphere, surface and ground waters, and soil systems. Pertinent environmental laws are described, simple quantitative engineering

models are developed, and qualitative descriptions of environmental engineering control technologies are presented. 3hrs. rec. 9 units. Spring
Prerequisite(s): 06-101 or 12-100.

- 12-352 Introduction to Environmental Engineering Lab**
(Required for CEE students, not for others) Laboratory and field experiments that illustrate the basic principles of environmental engineering. 1 hr. lab. 3 units.
Offered: Spring
Co-requisites: 12-251.
- 12-271 Introduction to Computer Applications in Civil and Environmental Engineering**
Introduction to the use of computer-based applications in civil engineering, using generic tools such as spread-sheets, equation solvers and computer graphics. Discussion of the role of computer-based methods in civil engineering practice. 3 hrs. rec. 9 units. Offered: Spring.
Prerequisite(s): 21-115 and 21-116 and 33-106.
- 12-301 CEE Projects**
Basic elements of civil and environmental engineering projects, from project conception through design, to implementation and operation. Project components are explored through formal instruction combined with analysis of actual engineering projects and student team activities. The course is intended to develop skills and understanding related to the application of engineering and science principles, approximations, empiricism, and experience to engineering projects; basic theory and practice of design; the importance and challenge of team efforts and effective communication; and the utility of measurements, modeling, visualization, quality control, and engineering graphics. 4 hrs. rec. 12 units.
Offered: Fall.
Prerequisite(s): 12-235 and 12-251 and 12-271.
- 12-231 Solid Mechanics**
Analysis of deformable bodies incorporating concepts of stress, strain, mechanical properties of materials, and geometric compatibility. Response under axial loads, torsion, bending, transverse shear, and combined loadings. Stress and strain transformations and Mohr's circles, deflections of beams and shafts, buckling of columns. 9 units. Offered: Spring
Prerequisite(s): 12-235 Co-requisites: 21-259.
- 12-232 Solid Mechanics lab
Analysis of stress-strain relationships, torsion of solid shafts, deformation due to bending, deformations in three dimensions, Mohr's circle representation of stress and strain, buckling of slender columns. Laboratory experiments and reports associated with theoretical concepts. 1 hr. lab.

3 units. Offered: Spring
Prerequisite(s): 12-235 Co-requisites: 12-331.

- 12-335 Soil Mechanics**
Sampling, testing and identification of soils. Physical, chemical and hydraulic characteristics. Stress-strain-strength relationships for soils. Permeability, seepage, consolidation, and shear strength, with applications to deformation and stability problems, including earth dams, foundations, retaining walls, slopes and landfills. 3 hrs. rec. 9 units. Offered: Spring.
Prerequisite(s): 12-331 Co-requisites: 12-355.
- 12-336 Soil Mechanics and Materials Laboratory**
Examination of material properties and behavior of soils, concrete, steel, polymers, and timber. 1 hr. lab. 3 units. Offered: Spring.
Prerequisite(s): 09-105 and 27-357 and 33-107.
- 12-355 Fluid Mechanics**
Fluid characteristics; continuity, momentum and energy equations; dynamic similitude; laminar and turbulent boundary layers; flow in pipes; lift and drag on immersed bodies; open channel flow. 9 units. Offered: Spring.
Co-requisites: 21-260, 21-259.
- 12-356 Fluid Mechanics Lab**
Fluid properties: density, specific gravity, viscosity; fluid characteristics; continuity, conservation of energy; fluid behavior: center of pressure, pipe flow, open channel flow. Laboratory experiments illustrating basic principles. 1 hr. lab. 3 units. Offered: Spring.
Co-requisites: 12-355.
- 12-357 Materials Lab**
Examination of materials properties and behavior of concrete, masonry, and timber. 3 units.
Prerequisite(s): 27-357
- 12-390 CEE Co-op**
- 12-401 Civil and Environmental Engineering Design**
Methodology for formulating and solving design problems, characterized by incomplete specifications, open-ended solution space, and partial evaluations. The methodology is illustrated and applied in the context of realistic design problems drawn from civil and environmental engineering. Design projects performed by teams, emphasizing collaborative problem-solving and preparation of written and oral reports. 2 hrs. rec., 3 hrs. lab. 15 units. Offered: Fall.
Prerequisite(s): Senior Standing in Civil and Environmental Engineering or instructor approval for Design Minors.
- 12-411 Engineering Economics**

Basic concepts of economic analysis and evaluation of alternative engineering projects for capital investment. Consideration of time value of money and common merit measures such as net present value and internal rate of return. Selection of independent projects and mutually exclusive proposals, using various methods of analysis. Capital budgeting and project financing. Influence of price level changes, depreciation and taxation on choice of alternatives. Uncertainty and risk in operation and financing. Important factors affecting investment decisions for private and public projects. 3 hrs. rec. 6 units. Offered: Fall, First Mini. Co-requisite: 36-217, 36-220 or equivalent.

CEE Advanced Undergraduate Courses

12-600 Special Topics: AutoCAD

The course provides an introduction to the fundamentals of computer-aided design (CAD) software. Students learn how to set up CAD projects using Autodesk's AutoCAD software. Topics include coordinates, lines, circles, arcs, zooms, snaps and grids, text, views, layers, plines, blocks, reference files, dimensioning, isometrics, 3D commands, surfaces, solids, and more. CAD standards for layers, plotting, and symbol libraries are also covered. The course includes development of a CAD project by each student. 3 units. Offered: Fall.

12-604 Special Topics: Transportation Engineering

Introduction to traffic engineering and highway design providing practical experience that can be used directly in the workforce. Course material will provide a solid foundation in preparing for the Professional Engineer exam. The course incorporates the soft side of transportation engineering with tasks such as traffic analyses and traffic studies and the hard side of transportation engineering including traffic signal design, signing design, pavement marking design, maintenance and protection of traffic during construction design, and highway design. 9 units. Offered: Spring .

12-605 Design and Construction

Introduction to steel, concrete, wood, and masonry construction methods and material selection; integration of design and constructability criteria; conformance of designs to applicable building and fire codes; preparation of plans and specifications; laboratory demonstration and experiments. 3 hrs. lab. 9 units. Offered: Spring. Prerequisite(s): 12-635, 27-357.

12-608 Special Topics: Implications of Engineering in a Global Society

Engineering developments do not operate in a vacuum. In today's global society, engineering interacts dynamically with economics and business, policy, the natural environment, consumer preferences, cultural differences, and personal values. This course aims to represent how engineering developments and

decisions relate to these other factors, and why these factors should be considered when creating engineering solutions. Topics may include genetically engineered foods, information and communication technology, transportation systems, the hydrogen economy, “green” infrastructure, and nanotechnology applications. The course will emphasize framing problems in a life cycle systems perspective and bounded by constraints and tradeoffs among economics, the environment, and societal issues 12 units. Offered: Spring.

12-610 **Special Topics: ICCM International Collaborative Construction Management**
Introduction to construction project management from owner’s perspective in organizing planning, design, construction and operation as an integrated process. Examination of labor productivity, material management and equipment utilization. Cost estimation, economic evaluation and financing of constructed facilities. Contracting, construction planning and fundamental scheduling procedures. Cost control, monitoring and accounting for construction. 3 hrs. rec. 9 units. Offered: Fall.
Prerequisite(s): 36-211, or 36-220, or equivalent.

12-611 **Project Management for Construction**
Introduction to construction project management from owner’s perspective in organizing planning, design, construction and operation as an integrated process. Examination of labor productivity, material management and equipment utilization. Cost estimation, economic evaluation and financing of constructed facilities. Contracting, construction planning and fundamental scheduling procedures. Cost control, monitoring and accounting for construction. 3 hrs. rec. 9 units. Offered: Fall.
Prerequisite(s): 36-211, or 36-220, or equivalent.

12-612 **Special Topics: The Business of Brownfields**
As defined by the U.S. Environmental Protection Agency, the term ‘brownfield site’ means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. The development or re-injection of these properties back into the community is a complex undertaking. The dimensions for brownfield development include history, infrastructure, legal/regulatory, environmental/ sustainability, economic development/ financing, land use, and community involvement. Fundamentally, however, brownfields are a ‘real estate deal’ and the business of getting the revitalizing a brownfield is challenging.

The course will explore the relevance of these dimensions to brownfield development with an emphasis in legal, technical, regulatory and financial issues. The course is organized to focus on one dimension of brownfield development per week. Readings (some optional, some required) will be assigned prior to the class so that the student can be prepared for class discussions. To the maximum extent possible, outside practitioners will make presentations each week. Grading will be based on weekly reading

synopses, class participation and a final project. The final project will be a group project to prepare a case study of a brownfield with special emphasis on the dimensions presented and discussed in class.

- 12-614** **Special Topics: Environmental Life & Cycle Assessment of Steel versus Wood in Residential and Commercial Construction**
Environmental impacts of construction materials and techniques are of increasing concern to developers and building owners. This project will assess the environmental impact of the use of steel and wood in construction using traditional product designs and optimized (new) product designs. The project course will involve some in-class lectures to familiarize students with the concept of life cycle assessment, with steel and wood manufacturing and production processes, with structural building design, and with construction management processes. Students will participate in field trips to steel and wood manufacturing facilities. Students will work in a multi-disciplinary team to evaluate the different materials and structural design options, to estimate the greenhouse gas emissions of the options, and to propose material and design choices for the construction industry. The goals of the course include exposing undergraduate students to multi-disciplinary teamwork, to the relationships between various engineering fields in decision-making for a final product design, to environmental impacts as a design constraint, and to the concept of life cycle assessment. units. Offered: Fall.
- 12-629** **Environmental Microbiology for Engineers**
This class provides a general introduction to microorganisms in natural and engineered environments. Selected topics include: cellular architecture, energetics and energy conservation, growth and catabolism; evolution and genetics; population and community dynamics; water and soil microbiology; biogeochemical cycling; biofilms; and microorganisms in wastewater, pollution attenuation, and bioremediation. 9 units. Offered: fall, every year.
Prerequisite(s): 03-121.
- 12-631** **Structural Design**
Selection, development, and proportioning of design solutions for structural systems. Exercises include synthesis of system geometry, interaction with other design requirements, and practice of modeling and analysis. Proportioning is treated for member design in steel and in reinforced concrete. 4 hrs. rec. 12 units.
Offered: Fall.
Prerequisite(s): 12-311.
- 12-635** **Structural Analysis**
Energy principles in structural mechanics. Basic concepts of force and displacement methods for analyzing redundant structural systems. Matrix methods utilizing the flexibility and stiffness concepts, with emphasis on the

direct stiffness method. 3 hrs. rec. 9 units. Offered: Fall.
Prerequisite(s): 12-331.

12-636

Geotechnical Engineering

Emphasis is on three major components of geotechnical engineering: (1) planning and design of exploration programs, interpretation of field and laboratory test data for use in geotechnical site characterization; (2) problem definition (e.g., slope stability, settlement analysis, etc.) and development of idealized analytical models; and (3) applications of analytical and numerical methods, particularly computer methods, applied to analysis and design. 3 hrs. rec. 9 units. Offered: Spring.

Prerequisite(s): 12-335.

12-648

Civil Engineering Project

Senior Research Project. This course is designed to give students the opportunity to work on an open-ended project under the direction of a faculty member in the Civil & Environmental Engineering department. To register for this course, a student must have the approval of the faculty member for both the research topic and the number of units. A student in this course must write a proposal and submit progress reports to the advisor. The student must also make a formal presentation of the project results and submit a final report to the department. 9-12 units. Offered: Fall/Spring.

Prerequisite(s): Senior standing in CEE and permission of the project advisor.

**12-651/
42-651**

Air Quality Engineering

Problems and methodologies for studies of environmental management, with an emphasis on air pollution. Key topics include source of pollutants; focusing on combustion chemistry for a hydrocarbon fuel; behavior of gaseous and particulate pollutants in the atmosphere, including the role of meteorology and the use of dispersion equations; effect of pollutants on human health and global climate; and procedures by which air pollution standards are developed and enforced by regulatory agencies. Statistical treatment of data is included at several places in the course. 3 hrs. rec. 9 units. Offered: Fall.

Prerequisite(s): 12-251, 12-355, 36-211.

12-657

Water Resources Engineering

Principles and applications of open channel flow. Hydrology of surface and ground water sources and the estimation of water requirements. Planning and design of water distribution and wastewater and storm water collection systems. 9 units. Offered: Spring, every other year.

12-658

Hydraulic Structure Design

Design of riverine and coastal structures, with emphasis on fluid mechanics and structural considerations, and use of empirical field information. Riverine topics include dams, levees, bridges, culverts; coastal topics include wave mechanics, jetties and groins, seawalls and breakwaters, marinas and harbors. Sustainability

issues in water resource system planning are discussed. 9 units. Offered: Spring, every other year.

Prerequisite(s): 12-235 and 12-355 (12-355 can be taken concurrently).

12-659

Special Topics: MatLab

This mini course is designed to be a practical introduction to engineering scientific computation. The topics of this class will include basic matrix computation, solving ordinary and partial differential equations, solving systems of linear equations, computing eigenvalues and eigenvectors, and basic signal processing and neural network techniques. Throughout the course, these scientific computation tools will be demonstrated using interactive scientific software called MATLAB. 6 units. Offered: Fall.

12-686

Issues in Environmental Nanotechnology

Issues in Environmental Nanotechnology will introduce the basic science and engineering concepts of nanoscience/nanotechnology and will discuss the social and cultural issues surrounding the introduction of nanotechnology into the global market place. Students will learn both basic science and technology and will discuss the opportunities for nanotechnology to improve the quality of life, as well as the potential negative effects of this emerging science on the environment and human health. The goal is to increase awareness of how nanotechnology interacts with the natural world, and at the same time to stimulate students who are focused on careers in environmental engineering to consider possible nanotechnological solutions to environmental problems. The course targets upper division undergraduates and graduate students from both the College of Engineering and the College of Science. Major topics include i) basic concepts in nanoscience and technology including the uniqueness of nanoscale processes and structures, ii) types and characterization methods of nanomaterials, iii) public perception of nanoscience, iv) current and future used of nanotechnology, and v) nanotechnology and the environment. 9 units. Offered: Fall.

12-690

Independent Study

In-depth investigation of a special topic in Civil and Environmental Engineering under the direction of a faculty member. The topic usually involves open-ended problems whose solution requires some elements of syntheses, analysis, construction, testing and evaluation of an engineering device or system. Prerequisite: Junior or Senior Standing in Civil and Environmental Engineering. 3-15 units.

CEE Graduate Courses

12-704

Probability and Estimation Methods for Engineering Systems

Overview of rules of probability, random variables, probability distribution functions, and random processes. Techniques for estimating the parameters of probability models and related statistical inference. Application to the analysis and design of engineered systems under conditions of variability and uncertainty.

12 units. Offered: Fall.
Prerequisite(s): 36-211, or 36-220 or equivalent.

12-705

Advanced Project Management

Studies of the planning, scheduling, and evaluation of large scale capital projects; construction safety and productivity; human factors in project management. Operational and financial risks of projects to an organization; cost estimation and controls; effects of inflation. Impact of large-scale projects on local environments. Prerequisite: 12-611 or equivalent. 6 units. Offered: Spring, mini session.

12-706

Civil Systems Planning, Pricing, and Finance

Economic framework for identifying and analyzing investment and operation options facing agencies and firms, (both in theory and in practice); economic efficiency, utilization, pricing, and investment; and multi-objective evaluation. 12 units. Offered: Fall.
Prerequisite(s): 12-441 or equivalent.

12-711

Project Management for Construction

This course is the graduate equivalent of course 12-611. In addition to the requirements of 12-611, a 3-unit project is required. The 12-611 course content includes an introduction to construction project management from the owner's perspective in organizing planning, design, construction and operation as an integrated process. Examination of labor productivity, material management and equipment utilization. Cost estimation, economic evaluation and financing of constructed facilities. Contracting, construction planning and fundamental scheduling procedures. Cost control, monitoring and accounting for construction. The 3-unit project involves students working in groups for in depth exploration of a project management concept covered in class or for hands-on experience of a state-of-the art project management tool. The emphasis will be on applying the concept or the tool on a real-life construction project. 3 hrs. rec. 12 units. Offered: Fall.
Prerequisite(s): 36-211, or 36-220 or equivalent.

12-712

Introduction to Sustainability Engineering

Society has generally assumed that the earth's resources are limitless and wastes can be disposed of without serious consequences, but the validity of these assumptions is now being challenged. This course begins with an overview of the concept of sustainability and its history, including changing attitudes and values toward technology and the environment through the twentieth century. Key conferences and reports that helped define sustainability are reviewed. Models for population growth, global food production, and global water resources are then presented, and current problems of land use, urbanization, and energy and material resources are discussed. Overall, the course material provides a context for engineering decisions in the twenty-first century, which are quite different from decisions of engineers in the past. Prerequisite: senior standing in

engineering or permission of the instructor. 6 units. Offered: First Mini, Fall.
Prerequisite(s): Senior standing in engineering or permission of the instructor.

12-713

Industrial Ecology and Sustainable Engineering Design

This course uses the context established in 12-712 to explore the solution space of engineers in tackling basic problems facing human civilization. The course begins with the concept of a system, using the earth's life support systems as examples. The potential damage of conventional engineering decisions on these life support systems is discussed. Models of industry based on life sciences are then explored, and tools for sustainable engineering are presented. These tools include metrics of sustainability, principles of design for the environment, methods for pollution prevention, and use of mass and energy balances in the design of sustainable systems. Finally, the principles and tools of sustainable engineering are used to explore solutions to some of the most challenging problems identified in 12-712.

6 units. Offered: Second Mini, Fall, Every Year.
Prerequisite(s): 12-712 or permission of instructor.

12-714

Life Cycle Assessment and Green Design

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This mini-course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software programs are used in assignments. A life cycle assessment project is required. Prerequisite: senior standing in engineering or permission of the instructor. 6 units. Offered: First Mini, Spring.
Prerequisite(s): Senior standing in engineering or permission of instructor.

12-715

Case Studies in Sustainability Engineering

The principles and tools of sustainability have yet to be applied on a large scale to solving real-world engineering problems. In this course, we explore the use of these principles and tools to various case studies. Prerequisite: 12-712, 12-714, or permission of the instructor. 6 units. Offered: Mini, Spring.
Prerequisite(s): 12-714 or permission of instructor.

12-716

Advanced Life Cycle Assessment

ISO 14040 series, Life Cycle Assessment (LCA) project management, advanced topics in goal and scope definition, inventory analysis, Life Cycle Impact Assessment (LCIA), interpretation, and use of LCA results for decision-making. A product system will be analyzed throughout the course, and each topic will be applied to the situation at hand as a group work. 6 units.
Offered: spring, mini session.

12-717

Symbolic Product and Process Modeling

This course will give students core concepts of general object-oriented modeling (e.g., UML and Express-G) and process modeling (IDEF0) approaches and techniques. It will provide an overview of product and process modeling trends in Architecture/Engineering/Construction industry and introduce key concepts for designing and developing symbolic model-based systems. (Rec. 3hrs) 6 units.
Offered: First Mini.

12-720

Water Resources Chemistry

A rigorous yet practical basis for applying the principles of physical chemistry to understanding the composition of natural waters and to the engineering of water and wastewater treatment processes. Topics covered include chemical equilibrium and kinetics; computer-aided problem solving; solid precipitation and dissolution; acid-base equilibria and buffering; oxidation and reduction reactions; sorption on solids; and coagulation and softening. Two laboratory sessions illustrate chemical principles of dilute aqueous systems. 12 units. Offered: Fall.

Prerequisite(s): introductory environmental engineering course or equivalent.

12-721

Environmental Biotechnology Principles

This course presents the theory of microbiological processes relevant to environmental systems. Environmental microbiology, including cell structure, metabolism, energetics, information storage, and microbial ecology, is followed by development of models for kinetics of suspended growth and fixed film biological systems. 4 hr. rec. 6 unit mini . Offered: Fall.

Prerequisite(s): graduate student or senior standing for undergraduates.

12-722

Wastewater Treatment: Design and Practice

Consideration of planning, process design, specifications and costing of facilities and systems for treatment of municipal and industrial wastewaters. The subject matter is developed through references to current practice, critique of completed design, design exercises, and field trips. 12 units. Offered: spring, every year.

Prerequisite(s): introductory environmental engineering course or equivalent.

**12-723/
42-723**

Biotechnology Applications in Natural Systems

This course presents applications of microbiology in the environment. Microbial ecology, biodegradation of specific contaminants, in situ natural attenuation and enhanced bioremediation will be discussed. 4 hr. rec. 6 unit mini . Offered: Fall, every other year.

Prerequisite(s): 12-721.

12-724

Biotechnology Applications in Engineered Systems

This course presents application of microbiology in water and wastewater treatment. Biological processes discussed include: aerobic municipal wastewater treatment, nitrification, denitrification, phosphorus removal, methanogenic treatment. Specific unit operations discussed include: activated sludge, trickling filters, fluidized beds, tertiary nutrient removal, methanogenesis, drinking water

treatment, and bioremediation. 4 hr. rec. 6 unit mini . Offered: Fall, every other year.

Prerequisite(s): 12-721.

12-725

Physicochemical Processes and Organic Compounds in Aquatic Systems

This course examines the major physical and chemical processes affecting the movement, fate and treatment of organic compounds in aquatic systems. The emphasis is on anthropogenic organic compounds. The course reviews basic concepts from physical organic chemistry, and examines the relationships between chemical structure, properties, and environmental behavior of organic compounds. Physical and chemical processes are important to the fate, treatment, and transformation of specific organic compounds are addressed including diffusion, volatilization, and sorption. Equilibrium and kinetic models based on these principles are used to predict the fate and transport of organic contaminants in the environment. 12 units. Offered: Spring.

Prerequisite(s): Undergraduate chemistry and introduction to environmental engineering courses or equivalent.

12-726

Mathematical Modeling of Environmental Quality Systems

Development and application of mathematical models for environmental systems. Material balance formulations and their solutions, computer implementation, model validation, uncertainty analysis, and use for projection and policy analysis. Applications to surface water, groundwater, atmospheric transport, indoor air pollution, and human exposure and risk. 12 units. Offered: Spring.

Prerequisite(s): 12-704 or equivalent.

12-727

Characterizing and Analyzing Environmental Samples and Systems

This course offers familiarity and hands on experience with the analytical tools used to characterize environmental samples, and to determine the extent of soil, water, and air pollution at a contaminated site. Sampling plans will be developed for a real or hypothetical site. Samples will be collected, and students will prepare and analyze them for specific chemical constituents using standard analytical methods during several laboratory sessions. Some of the laboratory sessions will illustrate chemical principles of dilute aqueous systems. The components of technical papers or journal articles (abstract, introduction, materials, and methods, etc.) will be reviewed, and results from the analyses will be presented in technical reports or research papers. 12 units. Offered: Spring.

Prerequisite(s): Graduate student standing; undergraduate or graduate chemistry (e.g. 12-720 or 12-725).

12-728

Special Topics: Remediation Engineering

Examination of the technical and management aspects of contaminated site remediation engineering, including site investigation, remedial planning and design, technology evaluation and selection, remedial construction, site closure, and post-closure monitoring and maintenance. In situ and ex situ remediation technologies are discussed. The risk assessment framework for contaminated site

remediation planning and design is presented. 3 hrs. rec. 12 units. Offered: Fall.
Prerequisite(s): introductory environmental engineering course.

12-729

Environmental Microbiology for Engineers

This course is intended for first-year graduate students who enroll in 12-629; additional work is required by way of a term project.
12 units. Offered: Fall.

12-740

Data Acquisition, Sensing, and Instrumentation for Infrastructure Systems

The intent of this course is to introduce students to the concepts, approaches and implementation issues associated with data acquisition for infrastructure systems. Students will be introduced to the types of data that are collected about infrastructure systems, excitation mechanisms, sensing technologies, data acquisition using sensors, signal pre-processing and post-processing techniques, and use of sensing in a variety of applications in construction and infrastructure management. Students will also gain experience with data acquisition hardware and software. 12 units. Offered: Fall.

Prerequisite(s): Graduate standing or permission of instructor.

**12-471/
48-741**

Data Management and Analysis

The intent of this course is to introduce students to database management systems and to knowledge discovery in database principles. Students will learn how to develop powerful tools for efficiently managing large amounts of civil engineering data so that it may persist safely over long periods of time. Students will be introduced to relational database systems and structured query languages. They will also be exposed to other existing data models. Students also will be introduced to data mining and analysis tools to discover patterns and knowledge from data. 12 units. Offered: Fall.

Prerequisite(s): graduate standing or permission of instructor.

**12-472/
48-742**

Computational Decision Support

The intent of this course is to introduce students to a number of fundamental concepts and computational approaches relevant to engineering decision support: fundamental logics used in engineering, knowledge-based decision support, approaches to optimization and search (deterministic-, stochastic- and genetic algorithm-based), and machine learning (decision tree analysis and artificial neural networks). The nature of these different approaches and their applicability to different types of engineering decision contexts in the civil infrastructure domain will also be discussed. 6 units. Offered: Spring.

Prerequisite(s): graduate standing or instructor permission.

12-743

Decision Contexts for Civil Infrastructure Domain

The intent of this course is to introduce students to several primary types of engineering decision making contexts that occur in the civil infrastructure domain: heuristic classification, model-based diagnosis, knowledge-based planning, and configuration. Decision frameworks and the

appropriate types of computational support tools will be discussed for each decision making context. 6 units. Offered: Spring, mini session.

Prerequisite(s): graduate standing or permission of instructor.

12-744 AIS Systems Project Preparation Course

This intent of this course is to prepare students for the project course 12-745 by exposing them to the following topics: technical communication; team-based problem solving and collaboration support technologies; individual and team ethics; library skills; readings/discussions relevant to the domain of project topic intended for 12-745. 3 units. Offered: Fall.

Prerequisite(s): graduate standing or permission of the instructor.

12-745 AIS Systems Project Course

This course will integrate and exercise students in a significant AIS system development project that is team-based, related to some area of infrastructure systems, industry driven, and built upon the knowledge, skills, and technologies learned in the core and specialist courses. 12 units.

Offered: Spring.

Prerequisite(s): 12-740 through 12-744, or permission of instructor.

12-750 Infrastructure Management

Introduction and overview to US and global infrastructure issues, focusing on transportation, energy, and wireless communications. Topics on condition, needs, and performance assessment methods for infrastructure management. Discussions of life cycle of planning, building, and maintaining infrastructure systems. State of the art in sensing and data collection/acquisition using information technology. Failure and interdependency analysis for management and security. Overall purpose is to understand the need for consideration of lifetime performance in the planning phase, to develop decision support metrics and systems for management, and to understand policy issues related to infrastructure design and maintenance. 3 hrs lec per week. 12 units. Offered: Spring.

Prerequisite(s): 12-706/73-359 or approval of instructor.

12-751 Air Quality Engineering

This course is intended for first-year graduate students who enroll in 12-651; additional work is required by way of a term project. 12 units. Offered: Fall.

12-755 Finite Element Method in Mechanics I

The basic theory and applications of the finite element method in mechanics are presented. Development of the FEM as a Galerkin method for numerical solution of boundary value problems. Applications to second-order steady problems, including heat conduction, elasticity, convective transport, viscous flow, and others. Introduction to advanced topics, including fourth-order equations, time dependence, and nonlinear problems. 12 units. Offered: Fall.

Prerequisite(s): Graduate standing, or consent of instructor.

12-757

Vibrations of Elastic Systems

This course is concerned with the response of discrete and continuous linear elastic systems subjected to dynamic excitation. Newton's equations, Lagrange's equations, and variational principles are used to formulate the problems; their solution is based primarily on direct methods, transform methods, and the modal method of analysis. Applications to discrete systems, as well as various continuous systems involving individual components such as rods, beams, membranes and plates, are presented. Numerical methods of solution are discussed, although emphasis is on problem solving and physical interpretation of results using analytical methods. 12 units. Offered: Fall, every other year. Prerequisite(s): Graduate standing, or consent of the instructor.

12-759

Computational Optimization of Systems Governed by Partial Differential Equations

This course provides an introduction to the numerical solution of nonlinear optimization problems that are governed by systems of partial differential equations (PDE), i.e. "simulation-based optimization". The focus of the course is on regularization, variational formulations, finite element approximation, and large-scale solvers for PDE-constrained optimization. Settings covered include inverse problems and parameter estimation, optimal design (including shape optimization), and optimal control. Students will develop numerical implementations and solutions of model problems in each of the classes using a high-level finite element toolkit. Prerequisites include a first course in numerical optimization and a course in finite element methods (equivalent to 12-755). This course is scheduled triennially. (3 hrs lec.) 12 units. Offered: every third year.

12-767

Special Topics: Infrastructure Management

Introductory topics include dispersive waves in strings, body waves in isotropic or anisotropic media, and wave reflection/refraction. Rayleigh surface waves, Stoneley and Scholte interface waves, and Love waves are introduced. Guided waves in rods, plates, layered media, and hollow cylinders are studied, as is the special case of horizontal shear. Models for source regions are introduced, with specific interest in solutions for transient excitations. Example applications include ultrasonic flaw detection, structural health monitoring, and seismic wave propagation. Laboratory experiments on ultrasonic wave generation and propagation are a required component of the course. 12 units. Offered: Spring.

12-769

Inelasticity: Theory and Computation

The first part of the course focuses on a theoretical framework for describing the macroscopic inelastic response of common materials like metals, polymers, and soils. The second part deals with computational approximation of such a framework within the finite element method. Topics: Theory - Physical origin of plasticity, stress-strain curve, yielding, work-hardening. Small and Finite-deformation theory - constitutive structure, normality; Hill's 'method of principal axes', work-conjugate stress measures corresponding to arbitrary strain measures, formulation of the boundary value problem of incremental equilibrium and analysis of uniqueness for rate-(in)dependent materials. Computational

Algorithms - isotropic hyperelasticity and hypoelasticity; rate-(in)dependent plasticity within the additive and multiplicative decompositions; linear and nonlinear viscoelasticity - material updates with exact/second-order accurate linearizations; incremental objectivity for hypoelasticity and finite plasticity under additive decomposition; element formulation to deal with near incompressibility. Prerequisites: first course in elasticity, graduate-level course in continuum mechanics, first course in finite element methods. This course is offered triennially. (3 hrs. lec.) 12 units. Offered: every third year. Prerequisite(s): Consent of Instructor.

12-786

Advanced Issues in Environmental Nanotechnology

Issues in Environmental Nanotechnology will introduce the basic science and engineering concepts of nanoscience/nanotechnology and will discuss the social and cultural issues surrounding the introduction of nanotechnology into the global market place. Students will learn both basic science and technology and will discuss the opportunities for nanotechnology to improve the quality of life, as well as the potential negative effects of this emerging science on the environment and human health. The goal is to increase awareness of how nanotechnology interacts with the natural world, and at the same time to stimulate students who are focused on careers in environmental engineering to consider possible nanotechnological solutions to environmental problems. The course targets upper division undergraduates and graduate students from both the College of Engineering and the College of Science. Major topics include i) basic concepts in nanoscience and technology including the uniqueness of nanoscale processes and structures, ii) types and characterization methods of nanomaterials, iii) public perception of nanoscience, iv) current and future used of nanotechnology, and v) nanotechnology and the environment. 12 units. Offered: Fall.

12-787

Special Topics in Computer Aided Engineering Education

Computing -- whether it is using off-the-shelf applications, writing programs, or building models -- pervades the field of Civil & Environmental Engineering. Yet we assume that undergraduates will develop the ability for what Jeannette Wing calls "Computational Thinking" without being taught it explicitly. The goal of this class is to look at the types of computational thinking that our undergraduates need both in school and in industry and then to design a sequence of undergraduate courses that provide them with these skills and knowledge. This course is designed for graduate students who are considering careers in academia and for those who are interested in understanding how computational thinking has had and will continue to have profound effects on the practice of Civil Engineering. 12 units. Offered: Fall.

12-790

Teaching Workshops

Four one-hour workshops will be conducted on the topics of grading, tutoring, and conducting review sessions, along with a follow-up evaluation session. Required of all graduate assistants in their first year. Offered: Fall.

- 12-791 Graduate Project**
Independent investigation and a comprehensive report on a project selected from a major area of study with the advice and approval of the faculty. Variable units. Offered: Fall and Spring.
Prerequisite(s): permission of advisor.
- 12-792 Advanced Independent Study**
In-depth investigation of selected advanced topics not offered in formal courses. By special arrangement upon demand and with approval of the instructor. 9-12 units. Offered: fall and spring.
Prerequisite(s): permission of instructor.
- 12-793 Graduate Teaching Assignment**
Teaching assignment responsibilities are wide and varied, depending on the needs of the faculty responsible for the course. Examples of some of the most common responsibilities are:
- Grading (homework, exams, labs, quizzes, reports)
 - Monitoring and assisting students in a laboratory environment
 - Preparing and teaching recitation
 - Assisting students during office hours
 - Creating problem sets and solutions
- n/a units. Offered: Fall and Spring.
Prerequisite(s): 12-790 - Department assignment with permission from advisor.
- 12-794 Graduate Seminar**
Forum for exchange of information on research conducted within the department, and for occasional presentations by external professionals. Required for all full-time graduate students. Separate seminars are conducted in each of the principal research areas of the department. 0 units. Offered: Fall and Spring.
- 12-799 Doctoral Thesis**
Independent research on significant fundamental problems in a major area of study, with the advice and approval of the faculty. Required of candidates for the degree of Doctor of Philosophy in Civil and Environmental Engineering.
Variable units. Offered: fall and spring.
- 12-995 Practicum in Civil and Environmental Engineering**
This Section R Course consists on an internship undertaken in absentia from Carnegie Mellon University. Units earned for this course are not eligible for graduate requirements. Enrollment is limited to graduate students in Civil and Environmental Engineering.

24-718

(Mechanical Engineering) Computational Fluid Mechanics

This course focuses on numerical techniques for spatial discretization: finite difference, finite element and spectral methods, and the solution of the Navier-Stokes equations. Stream function, vorticity and primitive variable formulations are applied to the solution of incompressible flows. Explicit, implicit, alternating-direction-implicit and approximate factorization methods are used to study compressible flows. A review of the finite difference methods which can be used to analyze elliptic, hyperbolic and parabolic equations and the concepts of stability, consistency and convergence are presented at the beginning of the course to familiarize the students with general numerical methods. 3 hrs. lec. 9 units. Offered: Fall or Spring.

24-751

(Mechanical Engineering) Introduction to Solid Mechanics I

This is a professionally-oriented course sequence concerned with two-dimensional problems in solid mechanics, including torsion, plane stress, plane strain and thermal stresses. In addition to elastic behavior of materials, plasticity is considered. The bending of flat plates is introduced. The emphasis is on solving problems, and a broad variety of methods employed without recourse to advanced mathematical techniques. 12 units. Offered: Fall.

24-752

(Mechanical Engineering) Introduction to Solid Mechanics II

This is a professionally-oriented course sequence concerned with two-dimensional problems in solid mechanics, including torsion, plane stress, plane strain and thermal stresses. In addition to elastic behavior of materials, plasticity is considered. The bending of flat plates is introduced. The emphasis is on solving problems, and a broad variety of methods employed without recourse to advanced mathematical techniques. 12 units. Offered: Spring.