Department of Civil and Environmental Engineering Courses

Note on Course Numbers

Each Carnegie Mellon course number begins with a two-digit prefix which designates the department offering the course (76-xxx courses are offered by the Department of English, etc.). Although each department maintains its own course numbering practices, typically the first digit after the prefix indicates the class level: xx-1xx courses are freshmen-level, xx-2xx courses are sophomore level, etc. xx-6xx courses may be either undergraduate senior-level or graduate-level, depending on the department. xx-7xx courses and higher are graduate-level. Please consult the Schedule of Classes (https://enr-apps.as.cmu.edu/open/SOC/SOCServlet) each semester for course offerings and for any necessary pre-requisites or co-requisites.

12-100 Introduction to Civil and Environmental Engineering
Fall and Spring: 12 units
Introduction to selected subfields in the discipline, such as structural engineering, construction project management, and environmental engineering. Problem-solving exercises apply fundamental concepts from these subfields to integrate the steps of analysis, synthesis, and evaluation through individual homework assignments 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 working in teams, scheduling, evaluating risk and making ethical decisions. In addition to regular lectures and project exercises, the course includes guest speakers and class demonstrations. 3 hrs., rec., 1 hr. lab.

12-201 Geology
Fall and Spring: 9 units
Introduction to physical geology; common rocks and rock-forming minerals and their chemical compositions/structure, physical properties, origins, and uses; geologic processes: surface and ground-water flow, volcanism, mountain-building, tectonics, glaciation, sedimentation, seismicity, and atmospheric and oceanic circulation.

12-212 Statics
Fall: 9 units
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.

12-215 Introduction to Professional Writing in CEE
Fall: 9 units
The objective of the course is to prepare students for writing technical reports and essays assigned in CEE courses and laboratories, writing professional letters and reports for internships and professional positions, preparing documents in a team setting, delivering individual and team oral presentations, and transforming information for several types of audiences (scientific accommodation). The course focuses on document purpose, organization and style; basic editing techniques; scientific accommodation; plagiarism and proper paraphrasing and summarizing; evaluating, citing and referencing sources; team communication strategies; oral presentations; and proper use of tables, graphics, and other visual aids in documents and presentations. Course activities include in-class exercises, peer workshops, and homework assignments to illustrate examples of good and poor communication and to practice technical communication skills. Concurrent with lectures and class activities, students draft and revise individual and team technical reports and will give individual and team oral presentations.

12-216 Special Topics: Research Skills and Topics in Civil Engineering
Spring: 3 units
Civil Engineering undergraduates will learn and practice research skills relevant to both academic research and engineering practice. Exposure to a breadth of cutting-edge Civil Engineering research topics and projects will be achieved through expert presentations and practical exercises.
Prerequisites: 12-212 and 12-100

12-231 Solid Mechanics
Spring: 9 units
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.
Prerequisite: 12-212

12-232 Solid Mechanics Lab
Spring: 3 units
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.
Prerequisite: 12-212

12-271 Introduction to Computer Application in Civil & Environmental Engineering
Spring: 9 units
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.
Prerequisites: 21-120 and (33-141 or 33-106)

12-301 Civil Environmental Engineering Projects
Fall: 9 units
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 role of project management and relevant business concepts are also discussed. 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 and public policy issues related to projects; basic theory and practice of design; the importance and challenge of team efforts; leadership, individual and group ethical behavior and effective communication; and the utility of measurements, modeling, visualization, quality control, and engineering graphics.
Prerequisites: 12-212 and 12-271

12-335 Soil Mechanics
Fall: 9 units
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.
Prerequisites: 33-142 and 12-231

12-336 Soil Mechanics Laboratory
Fall: 3 units
Examination of material properties and behavior of soils. Experiments include soil classification, permeability, compaction, consolidation and strength tests.
Prerequisite: 12-231

12-351 Environmental Engineering
Spring: 9 units
Provides a scientific and engineering basis for understanding environmental issues and problems. Introduces material and energy balances for tracking substances in the atmosphere, source 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.
Prerequisites: 12-355 and 09-105 and 21-260

12-352 Environmental Engineering Lab
Spring: 3 units
(Required for CEE students, not for others) Laboratory and field experiments that illustrate the basic principles of environmental engineering.

12-355 Fluid Mechanics
Fall: 9 units
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.
Prerequisites: 12-231 and 21-260 Min. grade C

12-356 Fluid Mechanics Lab
Fall: 3 units
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.

12-358 Materials Lab
Spring: 3 units
Examination of materials properties and behavior of concrete, masonry, and timber.
Prerequisite: 27-357

12-401 Civil & Environmental Engineering Design
Fall: 15 units
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. The importance of ethics, life long learning, and professional licensure are also discussed. Senior Standing in Civil and Environmental Engineering or instructor approval for Design Minors. Corequisite: 12-301, 12-6xx 9 unit course
Prerequisite: 12-301

12-411 Project Management for Construction
Fall: 9 units
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 and financing of constructed facilities. Contracting, construction planning and fundamental scheduling procedures. Cost control, monitoring and accounting for construction.
Prerequisite: 21-120 Min. grade C

12-421 Engineering Economics
Fall: 6 units
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.
Prerequisite: 21-120 Min. grade C

12-600 AutoCAD
Fall and Spring: 3 units
AutoCAD is mostly held online. 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.

12-606 Traffic Engineering
Fall: 6 units
Introduction to traffic engineering providing practical experience that can be used directly in the workforce. Course material will provide a solid foundation in preparing for the Transportation portion of the Professional Engineer exam. The course incorporates the initial planning side of transportation engineering with tasks such as traffic analyses, traffic studies and transportation/traffic engineering report writing.

12-610 Special Topic: Intl Collaborative Construction Mgmt
Spring: 9 units
This course is intended to provide a comprehensive overview of the life cycle of the facility development process and of relevant project management techniques. While primary emphasis is on the construction phase, the techniques and perspective apply to the other phases of the facility development process as well. Students learn not only how to develop construction estimates and schedules, but also, globalization issues, methods to work on multicultural teams, negotiation techniques, and methods to improve international collaboration enhanced by the use of Information Technology. Students work in international teams to collaborate from remote locations via the Internet taking maximum advantage of information technology using commercially available software. Students also report on lessons learned on working with different cultures.

12-629 Environmental Microbiology for Engineers
Fall: 9 units
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.
Prerequisite: 03-121

12-631 Structural Design
Spring: 12 units
Design of structural members for bending moment, shear force, axial force, and combined axial force and bending. Reinforced concrete, structural steel, and composite beam construction are considered. Buckling effects in columns, beams and local plate segments are treated. Serviceability limits such as deflection and cracking are addressed. Design projects include the determination of loads and the selection of system geometry.
Prerequisite: 12-231

12-635 Structural Analysis
Fall: 9 units
Classical and matrix-based methods of structural analysis; energy principles in structural mechanics. Basic concepts of force and displacement methods for analyzing redundant structural systems. Matrix methods utilizing the flexibility (force) and stiffness (displacement) concepts.
Prerequisite: 12-231

12-636 Geotechnical Engineering
Spring: 9 units
Behavior of geotechnical structures; engineering design of geotechnical structures considering failure modes; uncertainties; economic issues, required design formats and relevant code provisions; performance requirements for foundations, subsurface investigations; allowable stress and LRFD design approaches; reliability-based design; shallow foundations; deep foundations; retaining structures; reinforced concrete foundations.
Prerequisite: 12-335

12-638 Special Topics: Behavior of Structural Systems
Spring: 9 units
Students will learn how structural systems work, the rationale behind design codes, and how to design structures that can resist complicated loads like wind and earthquakes. Topics will include: fundamentals of structural design theory, approximate methods of analysis, an overview of common structural systems, distribution of gravity and lateral loads, frames, shear walls, structural details for steel and reinforced concrete.
Prerequisites: 12-631 or 12-635

12-645 Smart Cities: Growth and Intelligent Transportation Systems
Fall: 6 units
Cities all around the world are being built and re-invented as smart cities utilizing information systems and innovative applications of data analytics. One major smart cities component is transportation. The Intelligent Transportation Systems (ITS) industry is expected to grow at a rate of 19% per year and reach $5.5 Billion in annual investment by 2020. This shifting dynamic provides great opportunity for improved transportation safety and efficiency but also poses challenging information systems and public policy challenges. Furthermore, there are new opportunities for professional-school graduates outside of engineering schools for employment in transportation planning and policy. This course is supported by CMU's Traffic21 Initiative and Technologies for Safe and Efficient Transportation (T-SET) University Transportation Center. Classes will feature guest lectures provided by T-SET faculty and industry and government ITS professionals.

12-648 CEE Senior Research Project
Fall and Spring
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. Senior standing in CEE and permission of the project advisor Units: 9-12

12-651 Air Quality Engineering
Fall: 9 units
The course provides a quantitative introduction to the processes that control atmospheric pollutants and the use of mass balance models to predict pollutant concentrations. We survey major processes including emission rates, atmospheric dispersion, chemistry, and deposition. The course includes discussion of basic atmospheric science and meteorology to support understanding air pollution behavior. Concepts in this area include vertical structure of the atmosphere, atmospheric general circulation, atmospheric stability, and boundary layer turbulence. The course also discusses briefly the negative impacts of air pollution on society and the regulatory framework for controlling pollution in the United States. The principles taught are applicable to a wide variety of air pollutants but special focus is given to tropospheric ozone and particulate matter. The course is intended for graduate students as well as advanced undergraduates. It assumes a knowledge of mass balances, fluid mechanics, chemistry, and statistics typical of an undergraduate engineer but is open to students from other scientific disciplines.

12-657 Water Resource Systems Engineering
Spring: 9 units
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.
Prerequisite: 12-355

12-659 Special Topics: Matlab
Fall: 6 units
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.

12-676 Special Topics: Fundamental Concepts and Methods of Structural Mechanics
Fall: 12 units
This course will cover topics including an Introduction to Structural Dynamics, consisting of single degree-of-freedom systems, linear multi-degree-of-freedom systems, and relevant properties of symmetric matrices; Wave Propagation, consisting of Elements of Linear Elasticity, Formulation of Wave Propagation Problems, and Mathematical Aspects of Equations Relevant to Wave Propagation; and Elements of numerical methods applied to structural dynamics and wave propagation (if time permits).

12-679 Special Topics: Intro to Meteorology
Fall: 12 units
The course targets entering doctoral students in atmospheric research, as well as interested upper-level undergraduates (juniors and seniors) and masters students across engineering and sciences. It will provide students with the basics of meteorology, with a focus on large-scale atmospheric motion. By the end of the term students will understand the basics of atmospheric dynamics, including horizontal and vertical motion, as well as the vertical structure of the atmosphere (atmospheric stability and boundary-layer dynamics). They will understand what makes weather happen and they will understand weather maps and charts. They will be able to critically watch the nightly weather forecast and be able to access available meteorological databases to make informed predictions of their own. Finally, they will understand atmospheric transport and boundary-layer dynamics, which will serve as a foundation for other coursework involving atmospheric transport and air-pollution if they are pursuing those topics more deeply.

12-680 Advanced Computing in CEE
Spring: 9 units
Students will learn to use general purpose software to solve engineering problems, be introduced to discipline specific software currently used in Civil Engineering practice, and learn about modeling civil and environmental engineering systems. The general purpose software includes MathCad, advanced Excel, and Bluebeam Revu. Students will be introduced to the underlying models in the software and some of the fundamental concepts that are used in the software.
Prerequisite: 12-271

12-686 Special Topics: Computational Materials Modeling for Structures
Spring: 12 units
The course examines current mathematical models for the macroscopic response of metals, rocks, soil, and polymers and how they are motivated; elements of the microscopic basis that can be assigned to such models; and methods for finite element implementations of such models. Undergraduate mechanics background, familiarity with basic tensor algebra and calculus and the equations of 2-d elasticity theory, and some exposure to the finite element method (or a strong desire to learn these topics by guided self-study) are assumed.

12-690 Independent Study
Fall and Spring
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. Junior or Senior Standing or with instructor permission in Civil and Environmental Engineering. Faculty approval required. 3 to 12 units

12-702 Fundamentals of Water Quality Engineering
Fall: 12 units
This course is a systematic overview of water quality engineering designed for students with no prior civil and environmental engineering background. Topics examined include physical, chemical, and biological characteristics of water; common water pollutants; basic water chemistry and micriobiology; mass and energy balances and their use in reactor analysis; physical, chemical and biological processes affecting natural water quality and the use of these processes in water supply and wastewater management systems; and selected problems in surface water and groundwater quality management. A background in college-level general chemistry, physics, calculus, and differential equations is assumed.

12-704 Probability and Estimation Methods for Engineering Systems
Fall: 12 units
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.

12-712 Introduction to Sustainable Engineering
Fall: 12 units
This course begins with an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the twentieth century. Models for population growth, global food production, and global water resources are then presented, and current problems such as land use, urbanization, and energy and material resources are 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. Prerequisite: senior/graduate standing in engineering or permission of the instructor.

12-714 Environmental Life Cycle Assessment
Spring: 12 units
Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes using the ISO 14040 family of standards. This includes goal and scoping definition, inventory analysis, life cycle impact assessment (LCIA), interpretation, and guidance for decision support. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software such as MATLAB, Excel, and Simapro are introduced and used in assignments. A group life cycle assessment project consistent with the principles and tools of sustainability to solve real-world engineering problems is required.
Prerequisites: (12-421 or 12-706) and 12-712

12-718 Environmental Engineering, Sustainability, and Science Project
Spring: 12 units
This course integrates and exercises students in a significant sustainable engineering and/or environmental project that is team-based and built upon the knowledge, skills, and technologies learned in the core and specialist courses in the EESS graduate curriculum.

12-720 Water Resources Chemistry
Fall: 12 units
This course provides 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; acid-base equilibria and buffering; solid precipitation and dissolution; oxidation and reduction reactions; adsorption on solids; and computer-aided problem solving. The primary objective of the course is to be able to formulate and solve chemical equilibrium models for complex aqueous systems. Knowledge of college-level general chemistry is assumed.

12-725 Fate, Transport & Physicochemical Processes of Orgnc Contaminants in Aqua Systms
Spring: 12 units
Examination of the major physical and chemical processes affecting the fate and treatment of organic compounds nanoparticles in aquatic systems. The emphasis is on anthropogenic organic compounds. The course will review some concepts from physical organic chemistry, and examine the relationships between chemical structure, properties, and environmental behavior of organic compounds. Chemical processes important to the fate, treatment, and biotransformation of specific organic compounds are addressed. Two laboratory sessions illustrate measurement techniques for organic compounds in water. 12-702 is a co- req for non environmental engineers or students who have not had and environmental engineering undergraduate course

12-726 Mathematical Modeling of Environmental Quality Systems
Spring: 12 units
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. Prerequisite: 12-704 or equivalent.

12-730 Special Topics: Environmental Nanotechnology
Spring: 12 units
This course 1) will introduce the basic science and engineering concepts of nanoscience and nanotechnology and 2) will discuss the societal 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 consequences of this emerging science on the environment and human health. The primary goal of the course is to increase student awareness of the how nanomaterials interact in natural and engineered environments. We will examine both the potential benefits of nanomaterials/nanotechnology for environmental applications (groundwater remediation, drinking water production) and the potential environmental and toxicological hazards associated with nanomaterials/ nanotechnology.

12-734 Special Topics: Structural Health Monitoring
Spring: 6 units
Structural health monitoring system, which enables us to automatically diagnose and prognose structural damage, is important to ensure safe and functional built environment. This area requires a multi-disciplinary approach that encompasses structural engineering, sensor technology, wireless communication, signal processing, and statistical analysis. This course introduces damage diagnosis algorithms using various model-based and signal-based methods for civil structures with an emphasis on the underlying physical interpretations and their practical usage. The methods include modal analysis, time-series modeling, Gaussian mixture modeling, hypothesis testing, frequency analysis, and various classification techniques. The course is lecture-based with assignments and a project. Youwill have an opportunity through a class project to explore various damage d iagnosis algorithms, choose one to implement, present your work to the class, and be peer-reviewed.

12-740 Data Acquisition
Fall: 6 units
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 is 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.

12-741 Data Management
Fall: 6 units
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.

12-746 Special Topics: Fundamental Python Prototyping for Infrastructure Systems
Fall: 6 units
This course uses the Python programming language to introduce fundamental programming approaches to students from civil and environmental engineering. No prerequisite required and students with no programming experience are recommended to take this course. This course will cover fundamental programming approaches, object-oriented programming concepts, graphical user interface design in Python, and file and database operation. Real-world examples from infrastructure management will be used in the class for demonstration and term project. Students will work individually and in teams to develop a series of applications that are potentially be used in real-world applications.

12-747 Sustainable Buildings
Fall: 6 units
This course will cover the basics of the design, retrofit and monitoring of buildings to achieve energy efficiency. We will introduce energy simulation tools, the fundamentals of the most important building systems (i.e., heating, cooling, ventilation, insulation, etc.) and the technologies that can be used to monitor their performance. Graduate Standing, or approval of instructor

12-748 Mechanical and Electrical System Design for Buildings
Fall: 6 units
Class will cover HVAC, Electrical, and Plumbing systems for buildings. We will calculate heat loss and heat gains manually and with computer programs and calculate operating costs with various fuels and system types. We will size building electrical systems and look at alternative generation, smart metering and new lighting systems. Plumbing will include sizing water, drain and vent lines along with system design. Focus of the class will be on energy conservation and use, and how future systems will meet this criteria. The final project will be the audit of a building on campus using what we learned. Graduate Standing, or approval of instructor.

12-749 Special Topics: Climate Change Adaptation
Fall: 6 units
While the specific timing and magnitude of climate change impacts are uncertain, long-lived civil engineering infrastructure will need to be resilient to these potential impacts. Engineers designing for climate change adaptation require the tools to maximize resiliency and minimize cost for existing and proposed energy, transportation, water, urban and other types of infrastructure. Students successfully completing this course will understand how climate change affects civil infrastructure and how to quantitatively incorporate resilient designs and co-benefits under uncertainty. Students will use open data to examine current adaptation engineering challenges, quantify solutions, and communicate their technical recommendations through policy briefs. Prerequisites: Graduate standing or consent of instructor.

12-752 Special Topics: Data-Driven Building Energy Management
Fall: 6 units
This course will introduce students to a variety of data acquisition and analysis techniques required to solve the challenges faced by facility managers when trying to optimize the performance of our existing building stock. The course assumes students are familiar with concepts in instrumentation, linear algebra, probability, statistics and programming, though this is not a strict requirement. Some of the specific topics that will be discussed include: non-intrusive load monitoring, direct load control for demand response and automatic localization of sensors in buildings.

12-755 Finite Elements in Mechanics I
Fall: 12 units
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.Prerequisite: Graduate standing or consent of instructor. Prerequisites: Graduate standing or consent of instructor.

12-765 Special Topics: International Climate Adaptation & Infrastructure Innovation
Fall: 6 units
Although an international problem, climate change will affect each country's critical infrastructure in diverse ways. This course will focus on understanding how international communities are adapting and innovating to reduce critical infrastructure risk. Students will be able to list and describe natural hazards affected by climate change, focusing on their impacts on natural and built critical infrastructure systems in physically, socially, and economically diverse countries. Students will then use cost-benefit analysis, the triple bottom line approach (physical, social, economic), and robust decision making to analyze, compare, and contrast different countries' responses. The class will culminate in a final paper and presentation on one country's approach to decision-making under uncertainty for adaptation. Learning Objectives: By the end of the semester, you should be able to: · Understand risk. o Define risk, hazard, vulnerability, exposure, adaptation, hazard mitigation, greenhouse gas mitigation. Explain the link between some natural hazards and climate change o List 10 natural hazards and their impacts on the international community. · Analyze outcomes/impacts. o Predict how physically, socially, and economically detrimental a given natural hazard will actually be in different critical infrastructure systems. o Compare and contrast different adaptations to reduce risk. · Create recommendations for improving adaptation in an international community

12-769 Continuum Mechanics of Materials
Fall: 12 units
The topics that shall be covered are (1) An overview of Cartesian tensors, (2) Kinematics and Deformation, (3) Conservation Principles, (4) Constitutive Relations for Fluids and Solids and Boundary Value Problems, and (5) Dynamics of Continuum Systems. An undergraduate background in mechanics, including statics, dynamics, and solid mechanics is assumed, as well as a background that includes multivariable integral and differential calculus. Prerequisites: Graduate standing or permission of instructor Corequisite: 24-751 - Intro to Solid Mechanics I

12-772 Inelasticity
Fall: 12 units
The first part of the course focuses on a theoretical framework for describing the macroscopic inelastic response of common materials like metals and polymers. 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. Exposure to graduate level introductory solid mechanics, finite element method, and continuum mechanics is desirable.

12-784 Special Topics:Advanced Multiscale Modeling & Computation Engineering Materials
Fall: 12 units
This course will deal with advanced topics in multiscale modeling. Specific topics will vary depending on student and instructor interest, but will be in the general area of theoretical analysis of multiscale problems, and application of the theoretical analysis to develop efficient numerical methods for such problems. The material presented will be at a level that assumes that students have a strong grounding in graduate level finite element methods, solid mechanics, continuum mechanics, and engineering mathematics.
Prerequisites: 12-769 and (24-751 or 12-755)

12-798 Professional Communication for CEE Grad Students
Fall: 3 units
The course reviews skills and techniques for preparing technical documents, professional letters, resumes, and presentations typically encountered in advanced degree programs and in research and development positions in the public and private sector. Class topics focus on document purpose and organization; researching technical sources; summarizing, paraphrasing, and citing sources; simplifying and revising techniques; and the proper use of tables, graphics, and other visual aids in documents and oral presentations. Course content emphasizes North American writing norms.