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 Courses (https://er-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.
Corequisites: 21-120 and 33-106.

12-201 Geology
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.
Corequisites: 12-100 and 21-122 and 33-106.

12-215 Introduction to Professional Writing in CEE
Spring: 3 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 delivering oral presentations. The course focuses on document purpose, organization and style; basic editing techniques; plagiarism and proper paraphrasing and summarizing; evaluating, citing and referencing sources; oral presentations; and proper use of tables, graphics, and other visual aids in documents and presentations. Course activities include in-class exercises and homework assignments to illustrate examples of good and poor communication and practice technical communication skills. Concurrent with lectures and class activities, students draft and revise a technical report and prepare and deliver a brief oral presentation.

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
Corequisite: 21-259.

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
Corequisite: 12-231.

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 spreadsheet, equation solvers and computer graphics. Discussion of the role of computer-based methods in civil engineering practice.
Prerequisites: 21-120 and 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: 12-231 and 33-107
Corequisite: 12-355.

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
Corequisite: 12-335.

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: 09-105 and 12-355 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.
Corequisite: 12-351.

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: 21-259 and 21-260.

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.
Corequisite: 12-355.
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 Corequisite: 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.

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. Senior Standing in Civil Engineering or approval of instructor. Prerequisite: 21-120.

12-600 AutoCAD
Fall: 3 units
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.

12-604 Transportation Engineering
Spring: 9 units
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 including traffic signal design, signing design, pavement marking design, maintenance and protection of traffic during construction design, and highway design.

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 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.
Corequisites: 12-358 and 27-357.

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.

12-648 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 Resources 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. This course is offered every other spring semester. Prerequisite: 12-355 Corequisite: 12-351.
12-658 Hydraulic Structures
Spring: 9 units
Theory and practice of design or riverine and coastal structures, including dams, levees, bridge piers, culverts, jetties and groins, seawalls, bulkheads, breakwaters, marinas in waterways, and related concepts from surface and ground water hydrology, and wave mechanics. This course is offered every other spring semester. Corequisite: 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.

12-679 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.

12-690 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 microbiology; 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 materials 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 scope 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 Sustainable Engineering 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. Prerequisite: 12-740 through 12-744, or permission of Instructor for 12-745; 12-712, 12-713, or permission of Instructor for 12-718 [corequisite 12-714] Prerequisites: 12-740 or 12-741 or 12-742 or 12-743 or 12-744 or 12-745 Corequisite: 12-714.

12-720 Water Resources Chemistry
Fall: 12 units
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.

12-725 Fate, Transport & Physicochemical Processes of Orgnc Contaminants in Aqua Sysys
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.

12-734 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. You will have an opportunity through a class project to explore various damage diagnosis 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: Python Prototyping for Infrastructure Systems
Fall: 6 units
Information technologies (IT) enable the fast development of modern infrastructure systems and bring new ways to design, install and manage them. More and more software/hardware systems are embedded in buildings, bridges, tunnels and other infrastructure systems. Programming is becoming a more and more important tool for modern civil engineers. This course uses the Python programming language to introduce fundamental programming approaches to students from civil and environmental engineering. No prerequisite required. This course will cover the Python programming fundamental, concepts of object-oriented programming, graphical user interface design, database operation, web-based application development, and several third-party libraries for data analysis and processing. Real-world examples from Facilities 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, which will be integrated into several software applications to be used in CMU.

12-747 Special Topics: Sustainable Buildings
Fall: 6 units
This course will cover the basics of the building, 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.

12-748 Special Topics: Mechanical and Electrical System Design for Buildings
Fall: 6 units
The course 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.

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. Prerequisite: 12-740.

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 Present 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.

12-798 Special Topics: 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. Attendance at the required seminar on academic integrity and ethics in writing for CEE graduate students is also a requirement of this course.