

# UNDERGRADUATE CURRICULUM

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### UNIVERSITY OF PITTSBURGH

#### DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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The civil engineer is concerned with safeguarding life, health, and property while promoting the general welfare. He or she is the designer of the public and private works that affect large segments of the population. However, because problems of expanding population and increasing human needs confront our civilization, the responsibility of the civil engineer extends beyond mere physical structures into the social, political, and economic welfare of this and other countries. In brief, the work of the civil engineer has a significant impact on the quality of life in all areas of modern society.

The civil engineer deals in environmental control and in the development or redevelopment of a geographic area through overall planning, as well as in the design, construction, and operation of structures and facilities for public and private use. This broad field of activity involves all kinds of structures for buildings, bridges and industrial installations; as well as soil mechanics and foundations; transportation systems, including highways, traffic, airports, and harbors; hydraulic engineering, including irrigation; water resources, including power plants and dams; water supply systems; waste disposal; air and water pollution, and environmental remediation.

The civil engineering program at the University of Pittsburgh has been long established: the first B.S. degree was awarded by the Department in 1846. The program begins with studies in the humanities, social sciences, physical sciences, and mathematics, and proceeds to the fundamental aspects of civil engineering. The curriculum focuses on the electives available for designing individualized programs suited to the student's career goals. Emphasis is placed on societal needs and ways of meeting those needs. Thus, the graduate is prepared to begin work in any of the several branches of civil engineering or to continue his or her education at the graduate level.

The first two terms of the engineering curriculum are common to all departments. The Civil Engineering program is designed for those students who enter the program at the end of their freshman year. Students make their specific departmental selections during the second term of the freshman year. Summer programs are available primarily to assist students who are not taking the structured curriculum on schedule. Students are expected to complete all prerequisite courses before advancing to the next term.

<u>Subject</u> <b>FIRST TERM</b>	<u>Credits</u>
An. Geom and Calc 1 (Math 0220)	4
Humanities Elective <sup>(a)</sup>	3
Chemistry for Engrs 1 (CHEM 0960)	3
Physics for Sc & Engrg 1 (PHYS 0174)	4
Intro. To Engr. Analysis (ENGR 0011)	3
Freshman Seminar 1 (ENGR 0081)	0
<b>Total 17</b>	

<u>Subject</u> <b>SECOND TERM</b>	<u>Credits</u>
An. Geom and Calc 2 (MATH 0230)	4
Humanities Elective <sup>(a)</sup>	3
Chemistry for Engrs 2 (CHEM 0970)	3
Physics for Sc & Engrg 2 (Phys 0175)	4
Intro. To Engr. Computing (ENGR 0012)	3
Freshman Seminar 2 (ENGR 0082)	0
<b>Total 17</b>	

<u>Subject</u> <b>THIRD TERM</b>	<u>Credits</u>
An. Geom and Calc 3 (MATH 0240)	4
Prob. & Stats. For Engr. 1 (ENGR 0020)	4
Statics for Civ/Env Engrs. (ENGR 0131) <sup>(b)</sup>	3
Computer Methods in CE I(CEE 0109)	3
Intro to Environ. Engr. (CEE 1503) <sup>(c)</sup>	3
Sophomore Seminar (CEE 0085)	0
Departmental Seminar (CEE 1085)	0
<b>Total 17</b>	

<u>Subject</u> <b>FOURTH TERM</b>	<u>Credits</u>
Differential Equations (MATH 0290)	3
Mech. Of Materials of CEE (ENGR 0141) <sup>(b)</sup>	3
Engrng. Economic Analysis (IE 1040)	3
Materials of Construction (CEE 1105)	3
Intro to Microec Theory (ECON 0100)	3
Science Elective	3
Departmental Seminar (CEE 1085)	0
<b>Total 18</b>	

<u>Subject</u> <b>FIFTH TERM</b>	<u>Credits</u>
Intro to Structural Analysis (CEE 1330) <sup>(c)</sup>	3
Fluid Mechanics (CEE 1402) <sup>(c)</sup>	3
Principles of Soil Mechanics (CEE 1811) <sup>(c)</sup>	3
Dynamics for CEE (ENGR 0151)	3
Social Science Elective <sup>(a)</sup>	3
Departmental Seminar (CEE 1085)	0
<b>Total 15</b>	

<u>Subject</u> <b>SIXTH TERM</b>	<u>Credits</u>
Construction Management (CEE 1200)	3
Hydrology & Water Resources (CEE 1412)	3
One of the following sustainability courses :	
CEE 1209, 1210, 1217, 1218 , ENGR 1610	3
CEE Design Elective <sup>(d)</sup>	3
Transportation Engrng. (CEE 1703)	3
Departmental Seminar (CEE 1085)	0
<b>Total 15</b>	

<u>Subject</u> <b>SEVENTH TERM</b>	<u>Credits</u>
Humanities or Social Science Elective <sup>(a)</sup>	3
CEE Design Elective <sup>(d)</sup>	3
CEE Design Elective <sup>(d)</sup>	3
CEE Design Elective <sup>(d)</sup>	3
Engineering Elective <sup>(f)</sup>	3
Departmental Seminar (CEE 1085)	0
<b>Total 15</b>	

<u>Subject</u> <b>EIGHTH TERM</b>	<u>Credits</u>
Humanities or Social Science Elective <sup>(a)</sup>	3
CEE Elective <sup>(e)</sup>	3
Senior Design Project (CEE 1233, 1333 1433, 1533, 1733 or 1833)	3
CEE Elective <sup>(e)</sup>	3
CEE Elective <sup>(e)</sup>	3
Departmental Seminar(CEE 1085)	0
<b>Total 15</b>	

Consult the Departmental Registration Guide for Requirements.

- (a) Humanity or Social Science Elective
- (b) ENGR 0131 and 0141 must pass with a "C" or higher
- (c) CEE 1330, 1402, 1503 and 1811 must pass with a "C-" or higher
- (d) Design Electives: Students must take one elective from each of these groups (1)Struc. CEE 1340 or 1341; (2) Wat. Res. 1410 or 2401 or 2405 (3) Envir. 1505 or 1513 or 1515, (4)Geot or Pvmt 1821 or 1714 or 1715 or 2814
- (e) Any non-required CEE undergraduate courses and 2000 level CEE graduate courses are suitable for CEE Electives.
- (f) The Engineering elective courses may be interchanged to meet the student's program needs upon approval of the advisor.

## ENGINEERING COURSES

### ENGR 0020: PROBABILITY AND STATISTICS FOR ENGINEERS 4 cr.

A basic Course in probability and statistics. Topics covered include: Data analysis, Probability, random Variables, Discrete and continuous probability distribution, estimation, Hypothesis testing, Regression analysis and quality control. **Prerequisites:** MATH 0230

### ENGR 0131: STATICS FOR CIVIL & ENVIRONMENTAL ENGINEERS 3 cr.

A basic course in statics. Utilizing the free-body diagram. The course covers forces and equilibria of particles, rigid bodies, surfaces, trusses, beams, cables, and other basic structural elements. Use is made of computers for problem solving. **Prerequisite:** PHYS 0174

### ENGR 0141: MECHANICS OF MATERIALS FOR CIVIL & ENVIRONMENTAL ENGINEERS 3 cr.

An introductory course in the mechanics of deformable bodies, with special application to the range of topics needed by Civil Engineers. The course material covers internal strains, stresses and deformations, which occur when a structure is subjected to applied loads. Problems with tie-in to practical design issues will be covered. **Prerequisite:** ENGR 0131

### ENGR 0151: DYNAMICS FOR CIVIL & ENVIRONMENTAL ENGINEERS 3 cr.

A basic course in dynamics. Utilizing the Newtonian Mechanics of Particles, the course covers kinematics and kinetics of particles, kinetics of systems of particles, work and energy, introduction to vibrations, single-degree-of-freedom systems, and two-degrees-of-freedom systems. Applications of dynamics in civil engineering problems. Use is made of computer solution to a two-story building vibration. **Prerequisites:** ENGR 0141 and MATH 0290

### ENGR 1630: UNDERGROUND COAL MINING 3 cr.

This course is an introductory course that covers the exploration, development and mining of coal deposits, the history of coal mining, the modern mining methods and operations, types of coal mining equipment, and the fundamentals of coal mine ground control and ventilation.

### ENGR 1631: INTRODUCTION TO MINING ENGINEERING 3 cr.

The course introduces students to: 1) the history and importance of mining, 2) the exploration and development of surface and underground mines, 3) modern mining methods and operations, 4) common mining equipment, 5) fundamentals of mine ground control and ventilation, 6) elements of coal preparation and mineral processing plants, and 7) mine health and safety management. It is designed to provide students with basic understanding of the primary elements of a mining operation and the engineering issues associated with operating a mine in a safe, effective, and sustainable manner. The mining industry is replete with technical jargon and specialized processes and machinery that require mastery by students prior to exploration of more technically complex engineering coursework. Introductory lectures and field trips help to prepare students for the rigors of studying the other mining engineering courses offered within the swanson school of engineering.

### ENGR 1634: ENVIRONMENTAL CONTROLS IN MINING 3 cr.

The course is designed to study the environmental impact of coal, stone, and other mining operation and examine the engineering controls used to mitigate these impacts. The examination begins with the exploration and permitting of the mine site, emphasizing important environmental issues. Next, the impacts of active mining on land and water use are outlined. Most of these issues are related to subsidence impacting surface structures and water movement both at the surface and underground. To complete the mine's life cycle, closure and remediation issues are investigated. Lastly, a detailed examination of the issues associated with abandoned mined-lands, i.e. acid-mine drainage, mass-wasting, fires, etc., are studied. Throughout the course, engineering controls that focus on mitigating the environmental impacts of mining are acknowledged and assessed.

### ENGR 1635: MINE VENTILATION ENGINEERING 3 cr.

This course provides the skills needed to analyze and design ventilation systems for underground mines based on 1) regulatory requirements, 2) health concerns for workers, 3) levels of dusts and toxic or

explosive gases present, 4) mining methods used, and 5) splitting and delivery of different quantities of air to various workplaces.

### ENGR 1636: ADVANCED MINING SYSTEMS 3 cr.

This course provides an in-depth discussion of underground mining methods, including room-and-pillar development, full and partial pillar extraction, longwall development / extraction and deep cover mining (>1500 ft of overburden). These modern mining methods are often done under challenging geologic environments, requiring innovative mine design layouts which utilize leading ground control and ventilation methodologies. These advanced mining systems need to meet or exceed existing health and safety standards and address relevant environmental issues

### ENGR 1637: STRATA CONTROL ENGINEERING 3 cr.

This course provides the skills needed to analyze and design ground control systems for underground mines based on 1) regulatory requirements, 2) safety concerns for workers, 3) stress and displacement characteristics, 4) proposed mining methods, and 5) local geologic conditions.

## CIVIL AND ENVIRONMENTAL ENGINEERING COURSES

Required of all new students in their first year after transferring into the civil engineering department from freshman engineering or other colleges, the sophomore seminar acquaints the students with the departmental programs in the various civil engineering sub-disciplines. It is conducted on weeks alternating with the departmental seminar. Co-requisite: CEE 1085.

### CEE 0085: SOPHOMORE SEMINAR 0 cr.

Required of all new students in their first year after transferring into the civil and environmental engineering department from freshman engineering or other colleges, the sophomore seminar acquaints the students with the departmental programs in the various civil engineering sub-disciplines. It is conducted on weeks alternating with the departmental seminar. Co-requisite: CEE 1085.

### CEE 0109: COMPUTER METHODS IN CIVIL ENGINEERING 1 3 cr.

This course teaches the use of CAD as a design tool. Coverage includes both 2D drawing, 3D drawing and rendering. Visual Basic programming is employed for constructing complex objects and to communicate with other programs. **Co-requisite:** ENGR 0012 and MATH 0240

### CEE 1085: DEPARTMENTAL SEMINAR 0 cr.

The departmental seminars are designed to acquaint the student with aspects of the engineering profession which are not normally encountered in classes and school activities. On weeks alternating with the departmental seminar, sophomores and other students who are new to the department attend a separate sophomore seminar where they become acquainted with what civil engineering is, and the requirements and prospects of the various sub-disciplines.

### CEE 1105: MATERIALS OF CONSTRUCTION 3 cr.

The nature, physical properties, including environmental aspects of civil engineering construction materials are discussed. Experimentation, where applicable, is utilized. **Co requisite:** ENGR 0141.

### CEE 1200: CONSTRUCTION MANAGEMENT 3 cr.

This course introduces undergraduates to the construction management processes including planning, financing, contract administration, and project scheduling and controlling. It is a practical course that provides a broad knowledge of managerial decision-making for young engineers. This is a basic course for all follow-on construction courses.

### CEE 1203: CONSTRUCTION PROFESSIONAL DEVELOPMENT 3 cr.

This course teaches the student how construction-related organizations (owner, designer, and contractor) are organized and managed. The course covers such topics as marketing, TQM, ethics, risk management and personnel management. The course emphasizes a professional perspective to the practice of

construction management and incorporates lectures by practitioners of various professions. **Prerequisite:** CEE 1200.

**CEE 1209: LIFE CYCLE ASSMNT METH & TOOLS** 3 cr.

This course teaches framework, methods, and tools that can be applied to decision making in the design, construction, operation, and maintenance of the build environment, particularly when reducing environmental impact of construction activities is a goal. Topics include the principles of life cycle assessment, case studies of applications of life cycle assessment, methods for life cycle inventory, and methods for life cycle impact assessment. The course will also include an in-depth critical review of rating systems, methods, and software. **Prerequisite:** MATH 0230

**CEE 1210: ENGINEERING AND SUSTAINABLE DEVELOPMENT** 3 cr.

This course is intended as an introductory interdisciplinary engineering course. Topics include principles of sustainable design in engineering, manufacturing, infrastructure, communications, and community development; overview of environmental issues for engineers; design for the environment; models of environmental processes; introduction to the use of life cycle assessment; and case studies examining the relationship of green design and the field of engineering.

**CEE 1211: RESOURCE USE AND ENVIRONMENTAL QUALITY IN CONSTRUCTION** 3 cr.

Green Building Construction class that addresses issues of quantifying and estimating mass and energy flows during the life cycle of buildings, including tools and methods for calculation and analysis of the resource (mass and energy) flows in constructing, operating, and maintaining the built environment. The course will include an introduction to sustainability, green materials and processes, calculation of resource flows, and software tools for modeling resource flows. **Co-requisite:** CEE 1200.

**CEE 1212: ENVIRONMENTAL MANAGEMENT** 3 cr.

Management issues and practices concerning environmental protection are examined. The course surveys current U.S. environmental laws and regulations as well as international issues such as multilateral environmental protection treaties, ISO 14000, and environmental protection under NAFTA.

**CEE 1216: SOLAR DESIGN AND FABRICATION** 3 cr.

A technical elective course covering residential solar design and fabrication. Students in this course will work on a team to design and construct an off-grid home whose heating, cooling, and lighting systems are primarily solar powered. The course will involve research, design, and hands-on application of innovative building systems. The end product of the team's work in this course is a functional home.

**CEE 1217: GREEN BUILDING DESIGN & CONSTRUCTION** 3 cr.

Understanding the Design and Construction of green buildings are key elements in green and sustainable engineering. This course teaches all of the major aspects of green building design and construction, including sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and design process. The United States green building council's leadership in energy and environmental design green building rating system is used to demonstrate one possible green building rating system. Life cycle thinking will be discussed to expand the focus from not only design and construction, but also use, operations, and decommissioning.

**CEE 1218: DESIGN FOR THE ENVIRONMENT** 3 cr.

Design for the Environment (DFE) is a specific set of design practices aimed at creating eco-efficient products and processes. Incorporating sustainability into product and process design as a design constraint is clearly a necessity, as all engineers must understand the limits on natural resources. Students will be introduced to the DFE toolbox which includes design for demanufacture, life cycle assessment, and world industry sustainability challenges and hands on lab experiences designed in conjunction with local industry and organization partners. The course is also intended to be inter-disciplinary between engineering and business students to foster a balance between sustainability design efforts and business plans and strategies. Students can expect that labs will consist of a mix of field trips to partner companies and labs at the university. A major aspect to the course will involve student partnerships with local companies; students will be challenged to apply their DFE skills to projects that address sustainability

challenges. Additionally, students will have the opportunity to participate in a summer residency to implement their project with their sponsor company at the end of the course.

**CEE 1233: CONSTRUCTION DESIGN PROJECT** 3 cr.

Consists of comprehensive projects with emphasis on the nature of engineering problem solving and creative aspects of design in managerial decision-making of construction in such areas as estimating, scheduling, methods, risk management, and finance. **Prerequisite:** CEE 1200.

**CEE 1330: INTRODUCTION TO STRUCTURAL ANALYSIS** 3 cr.

An introduction to linear analysis of statistically determinate, and indeterminate, elastic structural systems. **Prerequisites:** MATH 0290 and ENGR 0141

**CEE 1333: STRUCTURAL DESIGN PROJECT** 3 cr.

Comprehensive (capstone) structural design project for a building or a bridge, emphasizing conceptual design, design of footings and superstructure, and preparation of CAD drawings, a final written and a final oral report. **Prerequisite:** CEE 1340 and 1341.

**CEE 1340: CONCRETE STRUCTURES 1** 3 cr.

Behavior, strength and design of reinforced concrete beams, one-way slabs, short columns, footings and simple structures using the ACI code. **Prerequisites:** CEE 1105 and 1330.

**CEE 1341: STEEL STRUCTURES 1** 3 cr.

An introductory steel design course based on the load and resistance factor design philosophy. Fundamental topics related to tension members, columns, beams, beam-column and simple connections are treated.

**CEE 1370: INTRODUCTION TO NONDESTRUCTIVE EVALUATION AND STRUCTURAL HEALTH MONITORING** 3 cr.

The course aims at providing an overview of the different techniques for the nondestructive evaluation (NDE) and the structural health monitoring (SHM) of civil and aerospace structures. Techniques such as electrical resistance strain gauges, fiberoptic sensing and ultrasonics will be described within the framework of the NDE. Applications to materials characterization and defect detection will be discussed with emphasis on steel and composite structures. Global and local methods for SHM will be introduced with emphasis on vibration and ultrasonic methods, respectively. The course will also provide the essential tools necessary for the digital signal processing of ultrasonic data. Matlab and laboratory exercises on recent researches will be investigated.

**CEE 1402: FLUID MECHANICS** 4 cr.

A first course in fluid mechanics discussing basic principles and methods for studying static and dynamic behavior of fluids. In the laboratory students conduct experiments on fluid flow in pipes and open channels. **Prerequisites:** MATH 0290 and **Co-requisite:** ENGR 0141

**CEE 1410: WATER RESOURCES ENGINEERING** 3 cr.

This course addresses fundamental and practical issues of water resources engineering. The increasing demand for sufficient water quantity and quality that is distributed in time and space forces engineers and policy makers to develop more comprehensive, complex, and ambitious plans for environmental and water systems. This course emphasizes understanding, formulating, and approaches of solving problems of water resources engineering. Quantitative overview of the water resources development, water resources problems, impacts of climate variability and global warming on water resources, and the fundamental principles and basic tools to solve these problems will be covered. Topics to be discussed also include introduction to basic concepts of hydrology, GIS (geographic information systems) applications, theory of unit hydrograph, frequency analysis, flood routing through reservoirs and rivers, introduction to rainfall-runoff analyses, and watershed modeling. **Prerequisite:** CEE 1402

**CEE 1412: HYDROLOGY AND WATER RESOURCES** 3 cr.

Hydrologic cycle, precipitation, infiltration, evaporation, runoff, flood routing, groundwater hydrology, well hydraulics, statistical analysis of hydrologic data, reservoirs, dams, and hydraulic structures. **Prerequisites:** CEE 1402 **Co-requisite:** ENGR 0020

CEE 1433: WATER RESOURCES DESIGN PROJECT 3 cr.

Consists of comprehensive projects with emphasis on the nature of engineering problem solving and the creative aspects of design. **Prerequisite:** 1 of the following CEE 2400, CEE 2401, CEE 2405, or CEE 2410.

CEE 1503: INTRODUCTION TO ENVIRONMENTAL ENGINEERING 3 cr.

Fundamentals of environmental science and engineering as applied to water and wastewater treatment, air quality control, and solid and hazardous waste management. **Prerequisite:** CHEM 0970

CEE 1505: WATR TRETMTNT & DISTB SYS DESGN 3 cr.

Stepwise development and process design, equipment selection, economic evaluation, layout, and operating guidelines for water treatment and distribution systems. **Prerequisite:** CEE 1503

CEE 1507: INDUSTRIAL WASTE MANAGEMENT 3 cr. (Cross-listed as CEE 2507 and CHE 2620)

Problems and approaches to industrial waste treatment and disposal; pollution prevention and sustainability, waste minimization, process selection, control, and resource recovery. **Prerequisite:** CEE 1503

CEE 1513: ENVIRONMENTAL ENGINEERING PROCESSES 3 cr.

Introduction to basic design concepts applied to water and wastewater treatment, air quality control, and solid and hazardous waste management. **Prerequisite:** CEE 1503.

CEE 1514: ENVIRONMENTAL IMPACT ASSESSMENT 3 cr.

Technical and procedural aspects of environmental impact analysis and assessment with emphasis on regulatory framework, characterization of impacts and their remediation, and the decision process when applied to engineering systems. **Prerequisite:** CEE 1503.

CEE 1515: WASTEWATER COLLECTION AND TREATMENT PLANT 3 cr.

Stepwise development and process design, equipment selection, economic evaluation, layout, and operating guidelines for wastewater collection and treatment systems. **Prerequisite:** CEE 1503

CEE 1523: ENVIRONMENTAL ENGINEERING LABORATORY 3 cr.

Chemical and biological laboratory procedures for environmental assessment and operation and control of environmental quality control systems. **Prerequisite:** CEE 1503.

CEE 1533: ENVIRONMENTAL ENGINEERING DESIGN PROJECT 3 cr.

Group design of an engineered system for environmental quality control. **Prerequisite:** One of the following Environmental Design courses: CEE 1505, 1507, 1513 or 1515.

CEE 1703: TRANSPORTATION ENGINEERING 3 cr.

Introduction to the design, planning, operation, management, and maintenance of transportation systems. Transportation planning inter-modal transportation systems (highways, air, rail, etc.). Transportation planning of highways, airports, and railroads with traffic flow models, capacity analysis, and safety. Concepts for designing facilities and systems area of study with life cycle costing procedures and criteria for optimization. **Prerequisite:** MATH 0240

CEE 1713: HIGHWAY ENGINEERING 3 cr.

Analysis of factors in developing highway transportation facility; traffic estimates and assignment; problems of highway geometrics and horizontal and vertical alignments and design standards; planning and location principles; earthwork and mass haul computations; surface drainage design; and concepts of highway administration and finance, highway design project.

CEE 1714: PAVEMENT DESIGN AND ANALYSIS 1 3 cr.

Concepts and principles in the structural design of pavements for highways and airfields including: traffic loads, climatic factors, soil and material characterization. Application of current pavement design practices and procedures. Economic evaluation of highway and airport pavements. **Prerequisite:** CEE 1105

CEE 1715: PAVEMENT MAINTENANCE AND REHABILITATION 3 cr.

Engineering concepts and information needed to maintain and rehabilitate pavements. Project evaluation, testing and analysis. Design of rigid and flexible overlays, and other methods of rehabilitation. Selection of rehabilitation alternatives. Analysis of the effects of maintenance activities on pavement performance. Initial and life cycle cost analysis of various rehabilitation alternatives. **Prerequisite:** CEE 1105

CEE 1717: COMPONENTS, PROPERTIES & DESIGN OF PORTLAND CEMENT CONCRETE 3 cr.

Examines the influence of constituent materials (cements, aggregates and admixtures) on the properties of fresh and hardened concrete; mix design handling and placement of concrete; and behavior of concrete under various types of loading and environment; test methods, designing concrete mixes for specific application. **Prerequisite:** CEE 1105

CEE 1718: ADV CONSTRUCTION & BITUM MATLS 3 cr.

Advanced construction and bituminous materials soils, soil stabilization, aggregates, bituminous materials and mixtures. Advanced topics in selection and design of bituminous materials. Asphalt cement, rheology, emulsions, chip seals, hot-mix asphalt design, visco-elastic characterization. **Prerequisite:** CEE 1105

CEE 1733: TRANSPORTATION DESIGN PROJECT 3 cr.

Consists of comprehensive projects with emphasis on the nature of engineering problem solving and the creative aspects of design. **Prerequisite:** One of the following Transportation Design courses: CEE 1714, or 1715 and CEE 2700.

CEE 1811: PRINCIPLES OF SOIL MECHANICS 4 cr.

Basic soil properties, permeability, capillarity and frost action, compaction, stresses in soil masses, two-dimensional seepage, compressibility, stress-strain-time behavior, and shear strength. **Prerequisite:** ENGR 0141

CEE 1821: FOUNDATION ENGINEERING 3 cr.

Application of the principles of soil mechanics to the analysis and design of foundations, the stability of slopes and retaining structures. **Prerequisite:** CEE 1811

CEE 1833: GEOTECHNICAL DESIGN PROJECT 3 cr.

Consists of comprehensive projects with emphasis on the nature of engineering problem solving and the creative aspects of design. **Prerequisite:** 1 of the following, CEE 1714 or 1715 or 1821 or 2814

CEE 1996: SPECIAL PROJECTS 1 – 4 cr.

CEE 1999: INDIVIDUAL DESIGN PROJECT 3 cr.

Individual or small group laboratory or analytical investigation. Intended for students inclined to a research or development career.

CEE 2100: NUMERICAL METHODS 3 cr.

Finite difference methods and finite element methods for parabolic, elliptic and hyperbolic differential equations. Also included are numerical methods for structure analysis and dynamics of vibration.

CEE 2201: CONSTRUCTION COST ESTIMATING 3 cr.

This course teaches the methodology for estimating construction costs. The course covers all types of costs and all types of construction. The student is introduced to standard reference materials and to computerized estimating systems. The course teaches methods and procedures for developing accurate estimates and the basis for follow-on cost control.

CEE 2202: CONSTRUCTION SCHEDULING 3 cr.

This course teaches the student the theory and practice of planning, scheduling, and controlling the time and cost of construction projects. The course covers various advanced techniques such as cost duration analysis, critical resource analysis, stochastic modeling, and cost control. The course teaches the use of contemporary computerized software systems with hands-on application.

CEE 2203 - CONSTRUCT METHODS AND EQUIPMENT 3 cr.

This course teaches the student how to plan, organize, and execute construction operations. The course includes typical operations in both building construction and engineering construction. The course describes how to properly construct in order to achieve quality and productivity objectives.

CEE 2204: CONSTRUCTION LAW AND RISK MANAGEMENT 3 cr.

This course introduces the student to the legal and risk management issues in construction. The course covers the principles of contract law and various legal areas affecting construction such as environmental regulations, insurance, bonds, tort liability, dispute resolution, and professional services.

CEE 2205: CONSTRUCTION FINANCE & COST CONTROL 3 cr.

This course introduces the student to the company level financial and accounting systems which are used in the construction industry, and to project control systems which are used to manage cost and time. The course includes such topics as financial accounting, cost accounting, financial statements, and variance analysis.

CEE 2206: CONSTRUCTION & COST OF ELECTRICAL SUPPLY 3 cr.

This course teaches basic construction and cost estimating methodologies for single and three-phase electrical distribution systems that include wiring, power, and controls. The course uses commercial estimating systems and the national electrical code.

CEE 2207: CONSTRUCTION & COST OF MECHANICAL SYSTEMS 3 cr.

This course teaches the student how to plan, organize, and execute mechanical construction operations; and the methodologies for estimating their costs. The course covers mechanical systems such as water (supply and waste), hvac, fire protection, and their controls.

CEE 2320: ADVANCED MECHANICS OF MATERIALS 3 cr.

The fundamentals of elasticity are introduced and related to various problems such as beams and bars on elastic foundations, unsymmetrical bending, torsion of thin walled members, curved bars, failure theories, and stability.

CEE 2324: COMPUTATIONAL NANOMECHANICS 3 cr.

This course teaches the essentials of computational nanomechanics, which concerns the use of modern computational tools to the analysis of materials at the nanoscale. These tools include molecular dynamics (MD), molecular mechanics (MM), and Monte Carlo methods. The course covers topics on classical mechanics, quantum mechanics, statistical mechanics, thermodynamics, and continuum mechanics, and their role in atomistic scale modeling and simulation. Atomic structure, bonding, and defects in materials as well as techniques for modeling them are also discussed. The course consists of a term project, in which students perform modeling and simulation of a nanomaterial system of their choice and analyze simulation results by visualization and data mining methods. Undergraduates may enroll in this course with the consent of the instructor.

CEE 2330: ADVANCED STRUCTURAL ANALYSIS 3 cr.

Theory and application of matrix stiffness and flexibility methods for analysis of framed structures. Computer implementation for the solution of two- and three-dimensional frames, trusses, and grid systems. **Prerequisite:** CEE 1330

CEE 2333: FUNDAMENTALS OF THE FINITE ELEMENT METHOD (Cross-Listed with BIOENG 2333) 3 cr.

Introduction to the finite element method and its application to various problems of elastic elements and structures. Both physical and variational approaches are used.

CEE 2341: STEEL STRUCTURES 2 3 cr.

Advanced design criteria for steel structures, including composite beams, columns, and frames; member and system stability; first- and second- order analysis of frames; and serviceability criteria.

CEE 2343: PRESTRESSED CONCRETE 3 cr.

Design of prestressed concrete beams and slabs, including shear and torsion effects.

CEE 2340: CONCRETE STRUCTURES 2 3 cr.

Advanced behavior, strength and design of reinforced concrete structures, including column and frame stability effects, two-way slabs, and serviceability criteria. Introduction to earthquake design concepts.

CEE 2344: DESIGN OF MASONRY STRUCTURES 3 cr.

Behavior, analysis, and design of clay and concrete masonry structural systems. Working stress and strength design methods will be utilized for rational design of reinforced and unreinforced masonry walls, pilasters, columns, and shear walls. The aci 530 building code and the uniform building code requirements will be utilized.

CEE 2346: REPAIR AND RETROFIT OF STRUCTURES 3 cr.

Introduction and use of performance-based design concepts. Analysis and modeling techniques for existing and repaired structures. Gravity and lateral load retrofit procedures. Selection, modeling and design of repair and/or retrofit measures for a variety of structures and building materials. Retrofit for blast loads.

CEE 2360: DYNAMICS OF STRUCTURES 3 cr.

Fundamentals of free and forced vibration of one and multidegree of freedom structures, including damping. Matrix formulation of multi-degree of freedom structures. Analytical and numerical methods for determining response; deflection and stress evaluation including damping effects.

CEE 2401: OPEN CHANNEL HYDRAULICS 3 cr.

Basic theories and principles of open channel flows (including flows in rivers and streams). Methods of calculating uniform flow, gradually varied flow, rapidly varied flow, and unsteady flow. Design of open channels. **Prerequisite:** CEE 1402

CEE 2405: GROUNDWATER HYDROLOGY 3 cr.

Mechanics of flow through porous media; Darcy's law; potential flow theory; steady and unsteady flow to wells; boundary effects and the method of images; practical aspects of well design, drilling and testing; numerical methods; leaky aquifer theory; analytical solutions. **Prerequisite:** CEE 1402

CEE 2414: ADVANCED HYDROLOGY 3 cr.

Linear hydrologic systems. Nonlinear models of catchment behavior. Queuing theory and water storage. Stochastic analysis and modeling of hydrologic processes. Simulation methods in surface water and water quality hydrology.

CEE 2420: HYDROLOGICAL MODELING 3 cr.

This course covers a wide range of topics related to hydrologic modeling, such as processes of water in the atmosphere, over land surface, and within soil. Advanced treatments for infiltration and evapotranspiration processes; energy budgets at the land surface; snow and snowmelt processes; applications of remote

sensing (e.g., satellites and radar); flood and drought, and issues related to advanced hydrologic modeling will be discussed. An operational hydrologic forecasting model will be used as an example for illustration. Students should be able to apply knowledge learned in class to solve practical problems, and to build hydrologic models of their own.

CEE 2500: ENVIRONMENTAL ENGINEERING MICROBIOLOGY 3 cr.  
Biological fundamentals as applied to the description and evaluation of natural environments and environmental quality control systems.

CEE 2501: ENVIRONMENTAL ENGINEERING CHEMISTRY 3 cr.  
Chemical fundamentals as applied to the description and evaluation of natural environments and environmental quality control systems.

CEE 2502: PHYSICAL-CHEMICAL PRINCIPLES IN ENVIRONMENTAL ENGINEERING 3 cr.  
Basic principles and applications of thermodynamics, reaction kinetics, equilibria, diffusion, and mass transfer.

CEE 2503: FIELD METHODS IN ENVIRONMENTAL ENGINEERING 3 cr.

CEE 2508: ATMOSPHERIC POLLUTION CONTROL (Cross-listed with CHE 2510) 3 cr.  
Industrial sources of air pollutants. Methods of sampling and measurement, control techniques. Dispersion models. Local and federal air pollution regulations.

CEE 2511 - ENVIRONMENTAL ENGINEERING PROCESS LABORATORY 3 cr.  
Chemical and biological laboratory procedures and techniques for instrumental analysis applied to evaluation of liquids and gases for environmental assessment and operation and control of environmental quality control systems. **Prerequisite:** CEE 1503

CEE 2700 - TRAFFIC MGMT AND OPERATIONS 3 cr.  
Introduction to traffic flow theory and characteristics. Highway capacity analysis. Basic traffic management and control.

CEE 2701 - TRAFFIC FLOW THEORY 3 cr.  
Traffic flow models; fluid flow and other physical analogies, car-following theory; stochastic models; markovian approaches; multi-lane models.

CEE 2702 - COMPUTER METH IN TRAFFIC ENGRNG 3 cr.  
Applications of contemporary traffic software. Theoretical foundations of the underlying models.

CEE 2710 - TRANSPORTATION SYSTEMS ANAL 1 3 cr.  
A range of traffic control systems including the analysis and design of traffic signals are discussed along with traffic signal systems and freeway control systems. Other topics covered include data collection for traffic control systems, optimization software and models; traffic signal hardware design; high occupancy vehicle lanes and systems selection and design and implementation.

CEE 2711 - ITS OPERATIONS AND DESIGN 3 cr.  
This course serves as an introduction to the operation and design of intelligent transportation systems (its). The course begins by offering a review of traffic signal operations in isolation and in coordinated systems. Additional intelligent transportation design elements associated with detection, communication, and information dispersal will be introduced and discussed. Other traffic management applications such as route guidance, incident detection, emergency management, safety enhancement, tolling facilities, and rural its applications will also be introduced and discussed. Other fields of its such as commercial vehicle systems and fleet operations as well as intelligent vehicle development and system wide deployment will

also be discussed. The course concludes with a discussion of the nation its architecture and standards as well as system deployment, planning, and evaluation.

CEE 2714 - PAVEMENT DESIGN AND ANALYSIS 3 cr.  
Concepts and principles in the structural design of pavements for highways and airfields including: traffic loads, climatic factors, soil and material characterization. Application of current pavement design practices and procedures. Economic evaluation of highway and airport pavements.

CEE 2715 - PAVEMENT MAINTENANCE AND REHAB 3 cr.  
Engineering concepts and information needed to maintain and rehabilitate pavements. Project evaluation, testing and analysis. Design of rigid and flexible overlays, and other methods of rehabilitation. Selection of rehabilitation alternatives. Analysis of the effects of maintenance activities on pavement performance. Initial and life cycle cost analysis of various rehabilitation alternatives.

CEE 2717 - CMPNTS, PROPRTS & DSGN OF PCC 3 cr.  
Examines the influence of constituent materials (cements, aggregates and admixtures) on the properties of fresh and hardened concrete, mix design handling and placement of concrete; and behavior of concrete under various types of loading and environment; test methods, designing concrete mixes for specific applications.

CEE 2718 - ADVANCED CONSTRUCTION AND BITUMINOUS MATERIALS 3 cr.  
Soils, soil stabilization, aggregates, bituminous materials and mixtures. Advanced topics in selection and design of bituminous materials. Asphalt cement, rheology, emulsions, chip seals, hot-mix asphalt design, visco-elastic characterization.

CEE 2720 - URBAN TRANSPORTATION PLANNING 3 cr.  
All aspects of the transportation planning process including transportation planning and decision making, transportation modeling, demand and supply analysis, transportation studies, environmental issues and project implementation.

CEE 2721 - TRAVEL DEMAND ANALYSIS 3 cr.  
The analysis of travel demand. Aggregate and disaggregate models. Activity and time budgets.

CEE 2722 - COMPUTER METHD IN TRANSPRTN PLN 3 cr.  
Students are introduced to some of the available software packages and their applications in transportation planning. The main focus of the course will be to learn available transportation planning software and have a hands-on experience with its implementation in a number of planning projects.

CEE 2730 - highway engineering 3 cr.  
Highway administration, classification, planning and programming. Geometric design of highways. Traffic characteristics and capacity analyses. Traffic operations and control. Highway design project.

CEE 2750 - project development and implementation 3 cr.  
Project development and implementation - 3 credits: this course provides overview of the process used in project programming and planning, design, construction and operation. The course will emphasize the process used for implementation of major projects with emphasis on construction management and how that task interfaces with other aspects of project development. Students will be involved in a team effort to conceptualize the project, plan alternatives, determine the environmental impact, examine design alternatives, prepare the project for construction documents, recommend award of the contract, manage the contract during construction and determine operational needs of the project.

CEE 2800: ENGINEERING GEOLOGY 3 cr.

Review of basic geologic principles with emphasis on the importance and influence of geology and geologic processes on engineering projects such as dam sites, foundations, tunnels, mine subsidence, landslides, highways, groundwater problems, and seismic studies.

CEE 2801: ADVANCED SOIL MECHANICS 3 cr.

Mathematical and graphical operations on stress and strain, seepage analysis and flow net, consolidation theory, upper and lower bound analysis, earth pressure theory, bearing capacity, and plasticity based soil models.

CEE 2802: GEOTECHNICAL ANALYSIS 3 cr.

Fundamentals of the analytical and numerical methods in geotechnical engineering are explored. Emphasis will be placed upon implementation and verification of various formulations into basic programs. Seepage, stress distribution, settlement, consolidation, sheetpiling wall, and beams on elastic foundations are some of the topics covered.

CEE 2803: EXPERIMENTAL SOIL MECHANICS 3 cr.

Laboratory investigation of soils; specific gravity, grain size distribution, plasticity, shrinkage, permeability, compaction, compressibility and shear strength characteristics; interpretation and use of test results in soil engineering. Report writing.

**Prerequisite:** CEE 2801

CEE 2814: SLOPES & EARTH RETAINING STRUCTURES 3 cr.

Conventional methods and recent advances in slope stability analyses; classical and modern earth pressure theories; design of rigid and flexible retaining structures; earth dams, their design and stability.

**Prerequisite:** CEE 1811

CEE 2818: ADVANCED FOUNDATION ENGINEERING 3 cr.

Subsurface exploration and control of groundwater; current procedures for the analysis, design, and construction of waterfront structures and shallow and deep foundations.

**Prerequisite:** CEE 2801

## COURSES IN OTHER DEPARTMENTS

CHEM 0960 & 0970: GENERAL CHEMISTRY FOR ENGINEERS 1 & 2 3 cr. each

These courses comprise a two-term introduction, open only to students enrolled in the School of Engineering, to the fundamental properties of matter. Applications to industrial and environmental chemistry and biochemistry are emphasized. Topics covered include stoichiometry; the properties of solids, liquids, and gases; thermo chemistry; and the electronic structure of atoms and molecules. Honors Sections are also available. CHEM 0960 includes three hours of lectures and one hour of recitation per week. CHEM 0970 has three hours of lectures and one afternoon of laboratory. CHEM 0960 is prerequisite for CHEM 0970. Honor Sections are available.

ECON 0100: INTRODUCTION TO MICROECONOMIC THEORY 3 cr.

Introduction to principles of economic analysis as applied to the study of prices and markets. The course builds a theoretical basis for understanding producer and consumer behavior, and prepares students to appreciate the importance of markets in our economic system.

GEOL 1445: GIS, GPS AND COMPUTER METHODS FOR EARTH SCIENTISTS 3 cr.

The goal of this course is to gain expertise in the methods of Geographic Information Systems using the Arc/Info software package on UNIX based workstations. No previous computer classes are required.

IE 1040: ENGINEERING ECONOMIC ANALYSIS 3 cr.

Time value of money, interest rate calculations, economic equivalence concepts, cost of capital, comparison of alternate investments, evaluating economic life and replacement alternatives, inflation, depreciation, depletion, impact of taxes on engineering economic decisions. **Prerequisite:** MATH 0220

MATH 0220: ANALYTIC GEOMETRY AND CALCULUS 1 4 cr.

This is the first of a sequence of three basic calculus courses. It covers the derivative and integral of functions of one variable and their applications.

MATH 0230: ANALYTIC GEOMETRY AND CALCULUS 2 4 cr.

This is the second of a sequence of three basic calculus courses. It covers the calculus of transcendental functions, techniques of integration, series of numbers and functions, polar coordinates, and conic sections. **Prerequisite:** MATH 0220

MATH 0240: ANALYTIC GEOMETRY AND CALCULUS 3 4 cr.

This is the third of a sequence of three basic calculus courses. It covers vectors and surfaces in space and the calculus of functions of several variables including partial derivatives and multiple integrals, Stokes theorem, and first order differential equations. **Prerequisite:** MATH 0230

MATH 0280: INTRODUCTION TO MATRICES AND LINEAR ALGEBRA 3 cr.

The principal topics which this course will cover include vectors, matrices, determinants, linear transformations, Eigen values and eigenvectors, and selected applications. **Prerequisite:** MATH 0230

MATH 0290: DIFFERENTIAL EQUATIONS 3 cr.

This course presents an introduction to the theory of differential equations from an applied perspective. Topics include linear and nonlinear ordinary differential equations, Laplace transform, and introduction to partial differential equations. **Prerequisite:** MATH 0230

PHYS 0174: BASIC PHYSICS FOR SCIENCE AND ENGINEERING 1 4 cr.

The integrated curriculum version of phys 0104, the first part of a two-term sequence (0174-0175) introduces students to the basic principles of mechanics. An effort has been made to achieve a better integration of physics with the first term of calculus, engineering, and chemistry. The theory of waves and the kinetic theory of gases will be discussed. **Co-requisite:** MATH 0220. Honors sections are also available (PHYS 0475).

PHYS 0175: BASIC PHYSICS FOR SCIENCE AND ENGINEERING 2 4 cr.

The integrated curriculum version of phys 0105, the second part of a two-term sequence (0174-0175), introduces students to the basic principles of physics. An effort has been made to achieve a better integration of physics with the first term of calculus, engineering, and chemistry. Modern physics (special relativity, elementary quantum mechanics, and atomic structure) will be discussed.

**Prerequisite:** PHYS 0174 **Co-requisite:** MATH 0230

## CIVIL & ENVIRONMENTAL ENGINEERING FACULTY AND THEIR SPECIALTY AREAS

Michael Babusci, P.E.

Joseph R. Beck, P.E.

Melissa Bilec, Ph. D.

George Bonnar

John Brigham, Ph. D.

Charles A. Buechel

Daniel D. Budny, Ph.D., P.E.

Leonard W. Casson, Ph.D., P.E.

Brian Greene, Ph. D.

Willie F. Harper, Jr., Ph.D., P.E.

Kent A. Harries, Ph.D., P.E.

Anthony Iannacchione, Ph. D., P.E.

Keith Johnson, P.E.

Transportation Engineering (Adjunct)

Construction Management (Adjunct)

Construction Management & Sustainability

Construction Management (Adjunct)

Structural Engineering

Construction Management (Adjunct)

Water Resources Engineering

Environmental Engineering

Water Resources Engineering (Adjunct)

Environmental Engineering

Structural Engineering

Mining Engineering

Transportation Engineering (Adjunct)

Brian Kozy, Ph.D., P.E.	Structural Engineering (Adjunct)
Amir Koubaa, Ph.D.	Geotechnical and Pavement Engineering
Amy Landis, Ph. D.	Sustainability Engineering
Xu Liang, Ph.D.	Water Resources Engineering
Jeen-Shang Lin, Sc.D., P.E.	Geotechnical Engineering
Werner C. Loehlein, P.E.	Water Resources Engineering (Adjunct)
Mark Magalotti, PE	Transportation Engineering (Adjunct)
Kenneth Marino, PE	Construction Management
Joseph Marriott, Ph. D.	Sustainability
Patrick Minnaugh	Structural Engineering
Ronald D. Neufeld, Ph.D., P.E.	Environmental Engineering
John F. Oyler, Ph.D., P.E.	Structural Engineering (Adjunct)
Rafael G. Quimpo, Ph.D., P.E.	Water Resources Engineering
Piervincenzo Rizzo, Ph.D.	Structural Engineering
Michael Rollage, BBA	Construction Management (Adjunct)
William Rost	Construction Management (Adjunct)
Daniel Su, Ph.D	Coal Mining Engineering (Adjunct)
Timothy Taylor	Construction Management (Adjunct)
Edward T. Telega, P.E.	Transportation Engineering (Adjunct)
Albert To, Ph. D.	Structural Engineering
Morteza A.M. Torkamani, Ph.D., P.E.	Structural Engineering
Luis E. Vallejo, Ph.D	Geotechnical Engineering
Julie M. Vandembosche, Ph.D., P.E.	Geotechnical and Pavement Engineering
Radisav D. Vidic, Ph.D., P.E.	Environmental Engineering
James Vitale, P.E.	Transportation Engineering

BIOENG	1531	Fundamentals of Biochemical Engineering
ENGR	0241	Fabrication and Design in Nanotechnology
ENGR	1050	Product Realization
ENGR	1076	Total Quality Management
ENGR	1500	Ethical Dilemmas: Balancing Cost, Risk, and Scheduling
ENGR	1600	Global Engr. Technology
ENGR	1630	Underground Coal Mining
ENGR	1631	Introduction to Mining Engineering
ENGR	1634	Mine Environmental Engineering
ENGR	1635	Mine Ventilation Engineering
ENGR	1636	Advanced Mining Systems
ENGR	1637	Strata Control Engineering
ENGR	1700	Introduction to Nuclear Engineering
ENGR	1869	Introduction to Electrical Engineering for Non EE's
COE/EE	0031	Linear Circuits and Analysis
COE/EE	0132	Digital Logic
EOH	2013	Environmental Health & Disease
EOH	2104	Introduction to Environmental & Occupational Health
EOH	2120	Chemical Physical & Biological Agents I
EOH	2504	Principles of Environmental Exposure
EOH	2505	Introduction to Occupational & Environmental Health
GEOL	1445	GIS, GPS and Computer Methods
IE	1038/2038	Integrated Product Development
IE	1054	Productivity Analysis
IE	1061	Human Factors Engineering
IE	1071	Probability & Statistics for Engineering II
IE	1081	Operations Research
IE	2030	Behavioral Systems Engineering
MEMS	0031	Electrical circuits
MEMS	1056	Energetics
MEMS	1172	Physical Metallurgy
PETE	1160	Petroleum Reservoir Engineering
PETE	1202	Petroleum Drilling and Production

(\* Additional courses may be accepted with the approval of the student advisor.

### APPROVED SCIENCE ELECTIVES (\*)

BIOSC	0150	Foundations of Biology I
BIOSC	0370	Ecology
BIOSC	0715	UHC Foundations of Biology I
BIOSC	1000	Biochemistry
BIOSC	1260	Aquatic Botany
BIOSC	1850	Microbiology
CHEM	0250	Introduction to Analytical Chemistry
CHEM	0310	Organic Chemistry I
CHEM	0320	Organic Chemistry II
GEOL	0040	Physical Geology
GEOL	0800	Geology
GEOL	0840	Earth System Science
GEOL	0860	Environmental Geology
GEOL	0870	The Planets
GEOL	0890	Physical Oceanography
GEOL	1445	GIS, GPS and Computer Methods
NROSCI	1017	Synaptic Transmission
PHYS	1341	Thermodynamics and Statistical Mechanics

### APPROVED ENGINEERING ELECTIVES (\*)

BIOENG	1050	Artificial Organs II
BIOENG	1150	Bioengineering Methods and Applications