UNDERGRADUATE CURRICULUM

UNIVERSITY OF PITTSBURGH

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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The civil and environmental engineer is concerned with safeguarding life, health, and property while promoting general welfare in society. They are the designer of the public and private works that affect all segments of the population. The responsibility of the civil and environmental 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 and environmental 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 – the infrastructure. This broad field of activity involves all kinds of structures for buildings, bridges and industrial installations; as well as earthworks 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 and environmental engineering program at the University of Pittsburgh is 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 and environmental engineering or to continue his or her education at the graduate level.

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UNDERGRADUATE CURRICULUM

The first two terms of the engineering curriculum are common to all departments. The Civil and Environmental 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.

Subject **FIRST TERM**	Credits
An. Geom and Calc 1 (Math 0220)	4
Humanities Elective [a]	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
Total 17	

Subject **SECOND TERM**	Credits
An. Geom and Calc 2 (MATH 0230)	4
Humanities Elective [a]	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
Total 17	

Subject **THIRD TERM**	Credits
An. Geom and Calc 3 (MATH 0240)	4
Prob. & Stats. For Engr. 1 (ENGR 0020)	4
Statics for Civ/Env Engrs. (ENGR 0131) [b]	3
Engrng. Economic Analysis (IE 1040)	3
Intro to Environ. Engr. (CEE 1503) [c]	3
Sophomore Seminar (CEE 0085)	0
Departmental Seminar (CEE 1085)	0
Total 17	

Subject **FOURTH TERM**	Credits
Differential Equations (MATH 0290)	3
Mech. Of Materials of CEE (ENGR 0141)[b]	3
Computer Methods in CE 1(CEE 0109)	3
Materials of Construction (CEE 1105)	3
Intro to Microec Theory (ECON 0100)	3
Science Elective	3
Departmental Seminar (CEE 1085)	0
Total 18	

Subject **FIFTH TERM**	Credits
Intro to Structural Analysis (CEE 1330) [c]	3
Fluid Mechanics (CEE 1402) [c]	3
Principles of Soil Mechanics (CEE 1811) [c]	3
Dynamics for CEE (ENGR 0151)	3
Social Science Elective [a]	3
Departmental Seminar (CEE 1085)	0
Total 15	

Subject **SIXTH TERM**	Credits
Construction Management (CEE 1200)	3
Hydrology & Water Resources (CEE 1412)	3
One of the following sustainability courses : CEE 1609, 1610, 1617, 1618 , ENGR 1610	3
CEE Design Elective [d][e]	3
Transportation Engrng. (CEE 1703)	3
Departmental Seminar (CEE 1085)	0
Total 15	

Subject **SEVENTH TERM**	Credits
Humanities or Social Science Elective [a]	3
CEE Design Elective [d] [e]	3
CEE Design Elective [d][e]	3
CEE Design Elective [d] [e]	3
Engineering Elective [f]	3
Departmental Seminar (CEE 1085)	0
Total 15	

Subject **EIGHTH TERM**	Credits
Humanities or Social Science Elective [a]	3
CEE Elective [e]	3
Senior Design Project (CEE 1233, 1333 1433, 1533, 1733 or 1833)	3
CEE Elective [e]	3
CEE Elective [e]	3
Departmental Seminar(CEE 1085)	0
Total 15	

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 1401 or 2405 (3) Envir. 1505 or 1513 or 1515, (4) Geot or Pvmt 1821 or 1714 or 1715 or 1814
(e) All design electives must pass with a "C-" grade or higher.
(f) Any non-required CEE undergraduate courses, Mining Engineering Courses with the ENGR classification, 2000 level CEE graduate courses are suitable for CEE Electives, and any ENGR course offered by the CEE Department
(f) The ENGR elective courses may be interchanged to meet the student's program needs upon approval of the coordinator

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 on and equilibrium 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 CEE 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 that 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-freedom systems, and two-degrees-of-freedom systems. Applications of dynamics in civil engineering problems. **Prerequisites:** ENGR 0141 and MATH 0290

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 1632: SUSTAINABLE DEVELOPMENT IN MINING: ECONOMICS, SOCIETY, AND ENVIRONMENT 3 cr.
The course begins by examining the needs of society and commercial entities engaged in mineral production. Well conceived and designed mineral or solid fuel projects exercise a balance between economic prosperity, environmental health, and social equality. These concepts are then integrated into a case study, where the feasibility of a proposed mining project is analyzed. This examination forms the underpinnings of a course project report.

ENGR 1633: MINERAL INDUSTRY RISK MANAGEMENT 3 cr.
Introduces the concepts and models used to create an understanding of the risk management approach. These include life cycle model, work process model, basic risk management framework, and the minerals industry risk management framework.

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 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.

ENGR 1638: MINING HEALTH AND SAFETY 3 cr.
Presents an overview of the health and safety issues within the mining industry and to examine current efforts to address these issues. In-depth discussion of health issues affecting mining include: diesel control, noise induced hearing loss, silicosis, coal mine dust monitoring and control, toxic substances, and toxic fumes. In-depth discussion of safety issues affecting mining include: explosives, falls of ground, mine inundation's, fire prevention, mine explosions, ventilation, methane control, emergency response and rescue, training, ergonomics, machine safety, and electrical safety.

ENGR 1639: MINE EVALUATION AND MANAGEMENT 3 cr.
Mine evaluation, an essential component of mineral resource management, is examined in terms of performing, investigating and reporting on mine sampling, mine evaluation, grade control and reserve estimation. Mine management relates the economic, governmental, social, regulatory, cost, labor, health, safety, and environmental aspects of mineral extraction to the management of the mining enterprise.

CIVIL AND ENVIRONMENTAL ENGINEERING COURSES

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 emphasizes the mathematics and problem-solving skills necessary to be an intelligent user of a variety of computational tools for engineering analysis. The first portion of the course focuses on linear algebra within the context of engineering problems. Concepts of numerical linear algebra are then introduced, followed by a brief introduction to additional discrete analysis tools such as numerical approximation and signal processing. Lastly, through the introduction of cad software and an individual term project, students are taught how to independently gain familiarity and confidence with engineering software. **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. This course has a laboratory component. **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 1202: 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. **Undergrad Prereq:** CEE 1200

CEE 1203: CONSTRUCTION PROFESSIONAL DEVELOPMENT 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. **Prerequisite:** CEE 1200.

CEE 1204: 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 1205: CONSTRUCTION FINANCE & COST CONTROL 3Cr.
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 1206: CONSTRUCTION & COST OF ELECTRIC 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 1207: CONSTRUCTION AND COST OF MECHANICAL SYSTEMS 3cr.
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 1221: 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. **Prerequisite:** CEE 1200

CEE 1230: BUILDING INFORMATION MODELING 3 cr.
The goal of this course is to introduce the students to building information modeling (BIM) and other new and evolving technologies which are revolutionizing the building and horizontal infrastructure construction industry. Students will learn how BIM and other innovative technologies are being adopted currently by progressive builders to streamline the construction process through enhanced coordination, visualization, logistical planning, cost estimation and analysis. They will also learn how these new tools are enabling (and in some instances requiring) new highly integrated processes that are redefining architecture, engineering, construction and operations (AECO) business relationships and delivery contracts. **Prereq:** CEE 1200

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 statically determinate, and indeterminate 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 or 1341 (preferably both).

CEE 1340: CONCRETE STRUCTURES 1 3 cr.
An introductory concrete design course covering the behavior, strength and design of reinforced concrete beams, one-way slabs, short columns, footings and simple structures using the ACI design 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 in the context of the AISC design specifications. **Prerequisites:** CEE 1105 and 1330.

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, fiber optic 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. **Prerequisites:** CEE 1105 and ENGR 0151.

CEE 1401: 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 1412

CEE 1402: FLUID MECHANICS 3 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 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 & 1412

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 1105, CEE 1402, and 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 TRETMNT & 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 & 1402

CEE 1511: 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 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 & 1402.

CEE 1514: ENVIRONEMENTAL 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 DESIGN 3 cr.
Stepwise development and process design, equipment selection, economic evaluation, layout, and operating guidelines for wastewater collection and treatment systems. **Prerequisite:** CEE 1503 & 1402

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, 1513 or 1515.

CEE 1609: LIFE CYCLE ASSMNT METH & TOOLS 3cr.
This class will introduce students to life cycle thinking and provide engineers with tools to assess the sustainability and environmental impact of a product, process, or activity. Life cycle assessment (LCA) principles, methods, tools, and challenges will be explored throughout the course. Topics include material and energy flow analysis, environmental indicators and metrics for sustainability, case studies of LCA applications, and impact assessment.

CEE 1610: 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 1611: 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 1612: 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 1616: 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 1617: 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 1618: 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 1700: TRAFFIC MANAGMENT AND OPERATIONS 3cr.
Introduction to traffic flow theory and characteristics, highway capacity analysis and basic traffic management and control.

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, transit, bicycles, pedestrians, etc.). Transportation planning of highways, and intersections with traffic flow models, capacity analysis, and traffic operations. Concepts for designing facilities and systems area of study with life cycle costing procedures and criteria for optimization. **Prerequisite:** MATH 0240

CEE 1710: TRANSPORTATION SYSTEMS ANALYSIS 1 3cr.
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 model; traffic signal hardware design, highway occupancy vehicle lanes and systems selection, design and implementation.

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 1811

CEE 1715: PAVEMENT MAINTENANCE AND REHABILITATION 3cr.
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 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 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 1720: 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. **Prerequisite:** CEE 1703

CEE 1725: PUBLIC TRANSPORTATION SYSTEMS 3cr.
This course is designed to give seniors an d graduate students a basic background in the planning operations and development of public transportation systems within the context of the overall transportation system.

CEE 1730: 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. **Prerequisite:** CEE 1703

CEE 1733: TRANSPORTATION DESIGN PROJECT 3cr.
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 1800: 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 1809: HYDRAULIC FRACTURING MECHANICS 3 cr.
This class will prepare students to wisely and critically design hydraulic fracturing treatments as well as make informed recommendations to employers, governments, and communities about the risks and benefits of hydraulic fracturing methods. Upon completion of this course, students will be equipped to use engineering formulae to estimate hydraulic fracture dimensions, evaluate strengths and weaknesses of various modeling approaches, characterize subsurface conditions from wellbore pressure analysis, make sound recommendations for monitoring, and compare and contrast approaches and risks for a range of application domains. **Prerequisite:** CEE 1330 and 1402

CEE 1811: PRINCIPLES OF SOIL MECHANICS 3 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 and 1330

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 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 ENGINEERING 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: CONSTRUCTION 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 2230: BUILDING INFORMATION MODELING 3 cr.
The goal of this course is to introduce the students to building information modeling (BIM) and other new and evolving technologies which are revolutionizing the building and horizontal infrastructure construction industry. Students will learn how BIM and other innovative technologies are being adopted currently by progressive builders to streamline the construction process through enhanced coordination, visualization, logistical planning, cost estimation and analysis. They will also learn how these new tools are enabling (and in some instances requiring) new highly integrated processes that are redefining architecture, engineering, construction and operations (AECO) business relationships and delivery contracts.

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. **Prerequisites:** CEE 1330 and 1340 or 1341.

CEE 2321: ELASTICITY, PLASTICITY and FRACTURE MECHANICS 3cr.
This course provides first-year graduate students with the fundamentals regarding mathematical derivations, mechanical models and numerical analyses in elasticity, plasticity and fracture mechanics. It is aimed at laying the foundation for the students for their future study and research in advanced mechanical problems. The main topics of this course includes 1) equilibrium and compatibility in elastic domains; 2) complex potential method for elasticity problems; 3) plasticity fundamentals; 4) linear elastic fracture mechanics; 5) stress intensity factors; 6) cohesive crack model and crack band model; 7) size effect and scaling; 8)probabilistic fracture mechanics; and 9) micromechanics.

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

[1]**CEE 2333: INTRODUCTION TO FINITE ELEMENTS (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 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. **Prerequisite:** CEE 1340

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. Introduction to concepts of plastic design. **Prerequisite:** CEE 1341

[1]**CEE 2343: PRESTRESSED CONCRETE 3 cr.**
Design of prestressed concrete beams and slabs, including shear and torsion effects. **Prerequisites:** CEE 1340 (2340 preferred).

[1]**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. **Prerequisites:** CEE 1340 and 1341 (2340 and 2341 preferred)

[1] these courses are rarely taken in an undergraduate program and require permission of the instructor and a minimum GPA.

CEE 2347: BRIDGE DESIGN 3cr.
Design of highway bridge structures from conception through operation. Topics include steel and concrete design, bridge delivery, bridge maintenance and operation, bridge inspection and rehabilitation. **Prerequisites:** CEE 1340 and 1341 (2340 and 2341 preferred)

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. **Prerequisites:** CEE 2330

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 2515: WASTEWATER COLLECTION AND TREATMENT PLANT DESIGN 3 cr.
Stepwise development and process design, equipment selection, economic evaluation, layout, and operating guidelines for wastewater collection and treatment systems.

CEE 2609: LIFE CYCLE ASSESSMENT METHODS AND TOOLS 3 cr.
This class will introduce students to life cycle thinking and provide engineers with tools to assess the sustainability and environmental impact of a product, process, or activity. Life cycle assessment (LCA) principles, methods, tools, and challenges will be explored throughout the course. Topics include material and energy flow analysis, environmental indicators and metrics for sustainability, case studies of LCA applications, and impact assessment.

CEE 2610: 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 2612: DESIGN AND ANALYSIS OF EXPERIMENTS 3 cr.
Principles of designing experiments, analysis of variance techniques for hypothesis testing, simultaneous confidence intervals, robust design and Taguchi methods, block designs, factorial experiments, random effects and mixed models, split plot designs, analysis of covariance, response surface design.

CEE 2617: GREEN BUILDING DESIGN AND 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 2618: 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 ecofriendly materials selection. Students will also be exposed to real 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 2700: TRAFFIC MGMNT AND OPERATIONS 3 cr.
Introduction to traffic flow theory and characteristics. Highway capacity analysis. Basic traffic management and control. **Prerequisite:** CEE 1703

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. **Prerequisite:** CEE 1703

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 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 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 2725: PUBLIC TRANSPORTATION SYSTEMS 3 cr.
This course is designed to give seniors and graduate students a basic background in the planning, operations and development of public transportation systems within the context of the overall transportation system.

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 2809: HYDRAULIC FRACTURING MECHANICS 3 cr.
This class will prepare students to wisely and critically design hydraulic fracturing treatments as well as make informed recommendations to employers, governments, and communities about the risks and benefits of hydraulic fracturing methods. Upon completion of this course, students will be equipped to use engineering formulae to estimate hydraulic fracture dimensions, evaluate strengths and weaknesses of various modeling approaches, characterize subsurface conditions from wellbore pressure analysis, make sound recommendations for monitoring, and compare and contrast approaches and risks for a range of application domains. **Prerequisite:** CEE 1330 and 1402

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.

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 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 CORRESPONDING PROGRAM AREAS

Jorge Abad, Ph.D.	Water Resources Engineering
Kyle Bibby, Ph.D.	Environmental Engineering
Melissa Bilec, Ph.D.	Sustainability & Green Design
John Brigham, Ph.D.	Structural Engineering
Daniel D. Budny, Ph.D., P.E.	Water Resources Engineering
Andrew Bunger, PhD.	Geotechnical Engineering
Leonard W. Casson, Ph.D., P.E., BCEE	Environmental Engineering
Leanne M. Gilbertson, Ph.D.	Sustainability & Green Design
Kent A. Harries, Ph.D., P.Eng.	Structural Engineering
Anthony Iannacchione, Ph. D., P.E., P.G.	Mining Engineering
Vikas Khanna, Ph.D.	Sustainability & Green Design
Xu Liang, Ph.D.	Water Resources Engineering
Jeen-Shang Lin, Sc.D., P.E.	Geotechnical Engineering
Mark Magalotti, PE, PhD	Transportation Engineering
Carla A. Ng, Ph.D.	Environmental Engineering
John F. Oyler, Ph.D., P.E.	Structural Engineering
Piervincenzo Rizzo, Ph.D.	Structural Engineering
John T. Sebastian	Construction Management
Morteza A.M. Torkamani, Ph.D., P.E.	Structural Engineering
Luis E. Vallejo, Ph.D	Geotechnical Engineering
Julie M. Vandenbossche, Ph.D., P.E.	Geotechnical and Pavement Engineering
Radisav D. Vidic, Ph.D., P.E., BCEE	Environmental Engineering
Qiang Yu, Ph.D	Structural Engineering

Adjunct Faculty

Danrick Alexander	Coal Mining Engineering
Charles A. Buechel	Construction Management
Daniel Cessna P.E.	Transportation Engineering
William Curry	Construction Management
Mark Dietrick	Construction Management
Richard Feder, AICP	Transportation Engineering
Keith Johnson, P.E.	Transportation Engineering
Kurt Karanovich	Construction Management
Werner C. Loehlein, P.E.	Water Resources Engineering
Jason Previte	Transportation Engineering
Michael Rollage, BBA	Construction Management
William Rost	Construction Management
Daniel Su, Ph.D	Coal Mining Engineering
Timothy Taylor	Construction Management
Edward T. Telega, P.E.	Transportation Engineering

APPROVED SCIENCE ELECTIVES (*)

ASTRON	0113	Intro to Astronomy
ASTRON	0087	Basics of Space Flight
ASTRON	0088	Stonehenge to Hubble
ASTRON	0089	Starts, Galaxies, and the Cosmos
ASTRON	1122	Solar System Extra Solar Planets
ASTRON	1121	Galaxies & Cosmology
CHEM	0260	Analytical Chemistry
CHEM	0310	Organic Chemistry I
CHEM	0320	Organic Chemistry II
CHEM	1130	Inorganic Chemistry
CHEM	1310	Synthetic Organic Chemistry
CHEM	1410	Physical Chemistry
CHEM	1810	Chemical Biology
BIOSC	0150	Foundations of Biology I
BIOSC	0160	Foundations of Biology II
BIOSC	0350	Genetics
BIOSC	0370	Ecology
BIOSC	0715	UHC Foundations of Biology I
BIOSC	0805	The Human Body
BIOSC	1000	Biochemistry
BIOSC	1040	Biological Management
BIOSC	1130	Evolution
BIOSC	1200	Vertebrate Morphology
BIOSC	1350	Plant Biology
BIOSC	1380	Global Ecology
BIOSC	1000	Biochemistry
BIOSC	1260	Aquatic Botany
GEOL	0040	Physical Geology
GEOL	0060	History of the Earth
GEOL	0800	Geology
GEOL	0802	Geology of the National Parks
GEOL	0840	Earth System Science
GEOL	0860	Environmental Geology
GEOL	0870	The Planets
GEOL	0890	Physical Oceanography
GEOL	1001	Mineralogy
GEOL	1003	Igneous & Metamorphic Petrology
GEOL	1020	Sedimentology & Stratigraphy
GEOL	1100	Structural Geology
GEOL	1051	Groundwater Geology
GEOL	1060	Geomorphology
GEOL	1339/1340	Environmental Issues: Mining & Gas-drilling Issues
GEOL	1445	GIS, GPS and Computer Methods
GEOL	1460	Introduction to Remote Sensing
GEOL	1630	Environmental Geochemistry (permission of instructor is needed)
GEOL	1640	Geologic & Environmental Hazards
NROSCI	0080	Brain & Behavior
NROSCI	0081	Drugs & Behavior
PHYS	0477	Int. Thermal & Modern Physics
PHYS	1331	Mechanics
PHYS	1375	Foundations of Nanosciene

APPROVED ENGINEERING ELECTIVES (*)

BIOENG	1050	Artificial Organs II
BIOENG	1150	Bioengineering Methods and Applications
BIOENG	1531	Fundamentals of Biochemical Engineering
COE/EE	0031	Linear Circuits and Analysis
COE/EE	0132	Digital Logic
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	1631	Introduction to Mining Engineering
ENGR	1632	Sustainable Development in Mining: Economics, Society, and Environment
ENGR	1633	Mineral Industry Risk Management
ENGR	1634	Environmental Controls in Engineering
ENGR	1635	Mine Ventilation Engineering
ENGR	1637	Strata Control Engineering
ENGR	1638	Mining Health and Safety
ENGR	1639	Mine Evaluation and Management
ENGR	1700	Introduction to Nuclear Engineering
ENGR	1869	Introduction to Electrical Engineering for Non EE's
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.
(e.g, general biology, geology, planetary science)