

# CIVIL & ENVIRONMENTAL ENGINEERING

Engineering Bldg. (13), Room 266  
 Phone: 805.756.2947  
 Email: ceenve@calpoly.edu  
<https://ceenve.calpoly.edu>

Department Chair: Charles Chadwell

Engineering Student Services  
 Engineering South (40), Room 115  
 Phone: 805.756.1461

## Academic Programs

Program name	Program type
Civil Engineering	BS
Cross Disciplinary Studies Minor in Heavy Civil	Minor
Environmental Engineering	BS
Civil and Environmental Engineering	MS

The Civil and Environmental Engineering Department at Cal Poly, San Luis Obispo offers a rigorous and engaging educational experience that fully embraces Cal Poly's "Learn by Doing" approach.

## Undergraduate Programs

### BS Civil Engineering

Graduates of a civil engineering program must have the engineering skills needed to plan, design, construct, and maintain infrastructure and industrial facilities. In addition, graduates must have the broad education necessary to communicate effectively with other engineers, architects, planners, administrators, government officials, and the general public. The faculty and staff of the Civil Engineering program at Cal Poly understand these needs and take pride in preparing their students for the challenges associated with engineering practice.

The Civil Engineering program at Cal Poly has quickly grown into one of the largest and most respected programs in California and the nation. The program consistently attracts top student candidates because of its modern, well-equipped laboratories, the close interaction that occurs between undergraduates and full-time faculty, and a strong reputation among employers in the civil engineering and construction industries. Scientific depth is included within the curriculum for those students who are interested in graduate study.

The Civil Engineering program recognizes the importance of student organizations and strongly supports the American Society of Civil Engineers (ASCE) Student Chapter, the Institute of Transportation Engineers (ITE), Engineers Without Borders (EWB), and Chi Epsilon (the national civil engineering honor society). These student groups, along with others, sponsor opportunities for professional development, community service, and social activities which help to complement the formal academic program. The ASCE, ITE, and EWB Student Chapters have been recognized and awarded nationally on multiple occasions for their outstanding work and efforts in leadership and scholarship.

The Civil Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. The program's mission is to prepare students for successful careers in civil engineering

by providing a high quality, practice-oriented education that emphasizes design project experiences, "hands-on" laboratory activities, and teamwork. The program's faculty, in consultation with civil engineering practitioners and alumni, have developed a number of educational objectives to support this mission. These objectives are:

1. Successfully perform engineering functions in Civil Engineering practice;
2. Communicate effectively with industry professionals, decision makers and community members;
3. Work in an ethical and professional manner to positively impact society and the environment in a regional, national and global context;
4. Pursue life-long learning and service to the profession through continuing education opportunities, professional organizations, leadership, graduate degrees and/or other certification; and
5. Progress toward professional licensure.

The undergraduate curriculum in civil engineering is designed to support the educational objectives. Therefore, the curriculum includes broad coverage of mathematics, engineering and basic sciences, liberal arts, humanities, and social sciences. The program also includes a number of required engineering courses designed to ensure students become proficient in a breadth of civil engineering sub-disciplines: geotechnical, construction, structural, transportation, environmental, and water resources.

All CE majors must complete a quarter course in professional practice and a two quarter senior design capstone sequence that focuses on current civil engineering design procedures, standards and multiple realistic constraints. The professional practice course includes topics on interpersonal communication, teamwork, leadership, and ethics. Together, the three quarters promote an understanding of the issues and skills to become a successful design professional.

Flexibility within the curriculum allows students to select from a wide range of upper division civil engineering technical electives. Students use these technical electives to focus in one of the five areas of civil engineering noted above or to design a "general" curriculum that allows for a broad range of civil engineering interests. Students should consult with a faculty advisor prior to selecting and enrolling in upper division civil engineering technical electives.

## BS Environmental Engineering

The BS program in Environmental Engineering is concerned with the interrelation of people, materials, and processes in a complex and changing environment. The broad field of environmental engineering includes control of air and water pollution, environmental health and safety, solid waste, hazardous waste management, and pollution prevention.

The program offers a sound background in the fundamentals of thermodynamics, fluid mechanics, mass transfer, water resources, and geotechnical engineering. The problem-oriented approach to instruction, in modern well-equipped laboratories, provides an excellent opportunity to gain understanding and experience of the discipline. The program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

The main focus of the program is to prepare graduates for practice in professional engineering. Thus, Cal Poly's "learn by doing" philosophy is emphasized by integrating design throughout the curriculum, especially

in the numerous design-centered laboratories. In the required senior design project, which is completed in a two-quarter set of capstone courses, students demonstrate their understanding of engineering knowledge and their ability to apply that knowledge creatively to practical problems.

The Environmental Engineering program educational objectives are that its graduates will:

- Apply environmental engineering principles to analyze and solve real-world engineering challenges.
- Think independently, engage in life-long learning, and continue their development as professionals.
- Be prepared to pursue graduate study and licensure.
- Communicate effectively, both orally and in writing, and collaborate successfully in teams.
- Address the ethical, societal, and global issues encountered in environmental engineering.

An engineering approach to the subject enables graduates of the program to pursue careers in industry, consulting firms, and public agencies concerned with air and water pollution control, groundwater, potable water treatment, solid waste management, and hazardous waste management.

Various program constituencies, such as graduates and employers, are consulted periodically for input on the appropriateness as well as the attainment of the educational objectives. Other indicators such as student/alumni placement and success rates in the statewide fundamentals in engineering examination are also used to evaluate attainment.

The Society of Environmental Engineers offers technical programs and other activities, including field trips to study typical installations of systems. Student memberships also are available in the Air and Waste Management Association, the California Water Pollution Control Association, and the Water Environment Federation.

## Cross Disciplinary Studies Minor in Heavy Civil

An interdisciplinary minor sponsored by the Civil and Environmental Engineering department and the Construction Management Department. For more information, see the Construction Management (<http://catalog.calpoly.edu/collegesandprograms/collegeofarchitectureandenvironmentaldesign/constructionmanagement/>) section of the catalog.

## Graduate Program MS Civil and Environmental Engineering General Characteristics

The Master of Science program in Civil and Environmental Engineering has the following objectives:

- Job-entry education for the more complex areas of engineering, such as research and development, innovative design, systems analysis and design, and managerial engineering;
- Updating opportunities for practicing engineers;
- Graduate preparation for further study in engineering, leading to the Doctor of Engineering or Ph.D. degree.

## Prerequisites

For admission as a classified graduate student, an applicant must hold a bachelor's degree in engineering or a closely related physical science with a minimum GPA of 3.0 in the last 90 quarter units (60 semester) attempted. Applicants are required to submit satisfactory scores for the General (Aptitude) Test of the Graduate Record Examination. An applicant who meets these standards but lacks prerequisite coursework may be admitted as a conditionally classified student and must make-up any deficiencies before advancement to classified graduate standing.

Information pertaining to specific requirements for admission to graduate standing (classified or conditionally classified) may be obtained from the Graduate Program Coordinator of the MS in Civil and Environmental Engineering program.

## Program of Study

Graduate students must file a formal study plan with their advisor, department, college and university graduate studies office by no later than the end of the quarter in which the 12th unit of approved courses is completed. The formal program of study must include a minimum of 45 units (at least 23 of which must be at the 500 level). With the graduate advisor's approval, students select their elective units in one of the following areas of study: geotechnical engineering, structural engineering, transportation and planning, or water resources and environmental engineering.

The broad curriculum requirements for the MS in Civil and Environmental Engineering are:

- a minimum of 45 total units;
- 2 units of Graduate Seminar (CE 591 and CE 592)
- a minimum of 20 units of advisor approved electives within the major;
- at least 23 units of the 45 unit program at the 500 level;
- a comprehensive examination (non-thesis option) or a written thesis with an oral defense (thesis option).

Two program options are available:

### Thesis option

36 units of advisor-approved coursework and 9 units of research/design resulting in a written thesis and oral defense examination administered by a panel of at least three faculty.

### Non-thesis option

45 units of advisor-approved coursework which includes 1-unit comprehensive examination consisting of written and oral components administered by a panel of three faculty (maximum of two opportunities to pass this examination). Not an option for the blended BS +MS program.

## Blended BS + MS Civil and Environmental Engineering Program

A blended program provides an accelerated route to a graduate professional degree, with simultaneous conferring of both Bachelor's and Master's degrees. Students in the blended program are provided with a seamless process whereby they can progress from undergraduate to graduate status. Students are required to complete all requirements for both degrees, including senior project for the Bachelor's degree.

A blended program is available for MS Civil and Environmental Engineering.

### Eligibility

Majors that are eligible for the blended program are:

- BS Civil Engineering
- BS Environmental Engineering

Participation in a blended program is based upon prior academic performance and other measures of professional promise. Refer to [Graduate Education \(http://catalog.calpoly.edu/graduateeducation/#graduateandpostbaccalaureateadmissionrequirements/\)](http://catalog.calpoly.edu/graduateeducation/#graduateandpostbaccalaureateadmissionrequirements/) for more information and for the minimum criteria required to be eligible for a blended program at Cal Poly. Contact the Graduate Program Coordinator in the Civil and Environmental Engineering department for any additional eligibility criteria.

### Program of Study

The blended program allows students to earn graduate credit for several of their senior electives, effectively decreasing the summed unit requirements for both degrees. Students in the blended program are required to complete both a senior project and a thesis by taking:

Select one of the following Series:	4-6	
<b>Series A</b>		
CE 466	Senior Design Project I	
CE 467	Senior Design Project II	
<b>Series B</b>		
CE 468	Community Engineering Senior Design Project I	
CE 469	Community Engineering Senior Design Project II	
<b>Series C</b>		
ENVE 466	Senior Project Design Laboratory I	
ENVE 467	Senior Project Design Laboratory II	
<b>Thesis</b>		
CE 599 or ENVE 599	Design Project (Thesis) Design Project (Thesis)	9

### CE Courses

#### CE 111. Introduction to Civil Engineering. 1 unit

CR/NC

Broad overview of the field of civil engineering, including professional societies and their student chapters, professional licensing and registration, professional codes of ethics, the elements of engineering design, and the scope of analysis and design activities undertaken by private- and public-sector civil design professionals. Credit/No Credit grading only. 1 lecture.

#### CE 112. Design Principles in Civil Engineering. 2 units

Brief introduction to the different technical areas of civil engineering, including engineering design process, basic design principles and failure scenarios, professionalism and licensing in Civil Engineering. 2 lectures.

#### CE 113. Computer Aided Drafting in Civil Engineering. 2 units

Computer-aided drawing (CAD) and related software to display and quantify engineering designs. Elements of engineering design drawings. Related topics in information technology. 2 laboratories.

#### CE 200. Special Problems. 1-2 units

CR/NC

Prerequisite: Consent of department chair.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter. Credit/No Credit grading only.

#### CE 204. Mechanics of Materials I. 3 units

Prerequisite: ME 211.

Stresses, strains, and deformations associated with axial, torsional, and flexural loading of bars, shafts, and beams. Analysis of elementary determinate and indeterminate mechanical and structural systems. 2 lectures, 1 activity.

#### CE 207. Mechanics of Materials II. 2 units

Prerequisite: CE 204.

Combined stress states including torsion, axial, shear, moment, and pressure vessel loadings. Principle stress/strain states. Basic failure criteria. Analysis of beam forces, moments, deflections, and rotations. Introduction to stability concepts including column buckling. 1 lecture, 1 activity.

#### CE 208. Mechanics of Materials. 5 units

Prerequisite: ME 211.

Stresses, strains, and deformations associated with axial, torsional, and flexural loading of bars, shafts, and beams. Combined stress states including torsion, axial, shear, moment, and pressure vessel loadings. Principle stress/strain states and basic failure criteria. Stability concepts including column buckling. Not open to students with credit in CE 204. 3 lectures, 2 laboratories.

#### CE 222. Introductory Experiments in Transportation Engineering. 1 unit

Application of urban transportation planning, design, and operations principles. Introduction to Engineering Economics in the context of transportation projects. Collect field traffic operations data and conduct analysis and report conclusions from collected data. Field trip required. 1 laboratory.

#### CE 251. Programming Applications in Engineering. 2 units

Prerequisite: CE 113; MATH 244; and CE 204 or CE 208 (CE 208 may be taken concurrently).

Concepts from basic programming theory introduced in the context of engineering applications. Topics include the application of programming constructs to demonstrate finite precision calculations, linear systems, linear programming, basic nonlinear systems, plotting, statistics, least squares, approximations, and solve related problems from civil and environmental engineering. 2 activities.

#### CE 259. Civil Engineering Materials. 2 units

Prerequisite: CE 204 or CE 208 (CE 208 may be taken concurrently).  
Corequisite: CE 113.

Experimental determination of mechanical properties of concrete, asphalt, and soils as required for engineering applications. Experimental verification of assumptions made in mechanics of materials procedures. Use of strain measuring devices. Preparation of technical reports. 2 laboratories.

**CE 270. Selected Topics. 1-4 units**

Prerequisite: Open to undergraduate students and consent of instructor.

Directed group study of selected topics. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

**CE 321. Fundamentals of Transportation Engineering. 3 units**

Prerequisite: PHYS 141; CE 259 or CM 113; or graduate standing.

The characteristics and functions of highway, air, rail, transit and other modes of urban and intercity transportation. Fundamentals of transportation design, operations, and planning. Evaluation of costs, benefits, and environmental considerations. 3 lectures.

**CE 322. Fundamentals of Transportation Engineering Laboratory. 1 unit**

Prerequisite: CE 222. Corequisite: CE 321.

Application of urban transportation planning and operations principles and the design of highway facilities. Experimentation with properties of pavement materials through laboratory/field testing as well as preparation of testing reports. Field trip required. 1 laboratory.

**CE 336. Water Resources Engineering. 4 units**

Prerequisite: ME 341 or ENVE 264. Concurrent: CE 337.

Hydraulics of pile flow. Open channel flow, groundwater, and hydrology. 4 lectures.

**CE 337. Hydraulics Laboratory. 1 unit**

Prerequisite: ME 341 or ENVE 264. Concurrent: CE 336.

Application of basic fluid dynamic principles to various mechanical systems. Exposure to experimental problems and techniques with guided laboratory projects related to civil engineering discipline. 1 laboratory.

**CE 352. Structural Engineering. 4 units**

Prerequisite: CE 207 or CE 208. Corequisite: CE 251.

Introduction to concepts of structural engineering including ASCE7 loads, vertical and lateral load path, flexible and rigid diaphragms, determinate vs indeterminate systems, and the use of computer programs to solve structural engineering problems. 3 lectures, 1 laboratory.

**CE 355. Reinforced Concrete Design. 4 units**

Prerequisite: CE 259 and CE 352.

Analytical and design principles of reinforced concrete in designing civil engineering systems. Origin of code requirements. Fundamentals of proportioning. Details of elements and structural systems. 3 lectures, 1 laboratory.

**CE 356. Structural Steel Design. 4 units**

Prerequisite: CE 352.

Design and behavior of the elements of steel structures. Design and analysis of bolted, welded and eccentric connections. Proportioning of members and connections. Introduction to plastic design, end plate connection, composite construction, shear connections and design of composite beams. 3 lectures, 1 laboratory.

**CE 371. Construction Management and Project Planning. 4 units**

Prerequisite: ARCE 106, CE 259 or CM 113.

Theory and practice of planning, scheduling, estimating, and reporting for construction projects. Fundamentals of scheduling logic including critical path, deterministic, and probabilistic scheduling; including the impact of constraints. Identifying resources and estimating time requirements for design activities and project operations. Not open to Architectural Engineering or Construction Management majors. 3 lectures, 1 activity. Crosslisted as CE/CM 371.

**CE 381. Geotechnical Engineering. 4 units**

Prerequisite: CE 207 or CE 208; ME 341 or ENVE 264. Concurrent: CE 382 (CE majors only).

Engineering geology, elementary mass-volume relations, clay-water interaction, soil classification, soil compaction, geostatic stress distributions, 1-D and 2-D steady-state flow, shear strength under drained and undrained conditions. 4 lectures.

**CE 382. Geotechnical Engineering Laboratory. 1 unit**

Corequisite: CE 381.

Use of standard laboratory test methods to determine physical, mechanical, and hydraulic properties of soil. 1 laboratory.

**CE 400. Special Problems. 1-2 units**

Prerequisite: Consent of department chair.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**CE 401. Advanced Mechanics of Materials. 4 units**

Prerequisite: CE 406 or ME 328.

Introduction to linear elasticity as a means for development of reduced order theories such as torsion, beams, columns, and plates from the general three-dimensional continuum. Energy methods as well as the application and limitation of these theories. 4 lectures.

**CE 403. Civil Engineering Design Competition. 1 unit**

Prerequisite: CE 207 or CE 208.

Design, build, test, and present a solution to a civil engineering problem posed by a student design competition. Total credit limited to 4 units. 1 laboratory.

**CE 404. Applied Finite Element Analysis. 4 units**

Prerequisite: BMED 410, and CE 207 or CE 208; or CE 406; or ME 328.

Finite element based solutions to engineering problems with an emphasis on elastostatic problems in structural mechanics. The power and pitfalls associated with the finite element method highlighted through practical modeling assignments. Introduces the use of commercial finite element codes. 3 lectures, 1 laboratory. Crosslisted as BMED/CE/ME 404.

**CE 405. Concrete Materials. 4 units**

Prerequisite: CE 259.

Supplementary cementitious materials and chemical admixtures and their incorporation into concrete mix designs. Design and testing of concrete for durability and other specialized properties. 3 lectures, 1 laboratory.

**CE 406. Structural Analysis. 5 units**

Prerequisite: CE 352.

Structural analysis of frames, trusses, and combined systems. Modern structural analysis theorems are presented along with discussion of their relation to classical methods. Specific topics include virtual forces, virtual displacements, compatibility, constraints and matrix formulations. Course may be offered in classroom-based or online format. 4 lectures, 1 laboratory.

**CE 407. Structural Dynamics. 4 units**

Prerequisite: CE 406 and ME 212.

Effect of vibration and transient loads on structural elements. Dynamics load factors, support motion, damping and natural frequencies of multidimensional structural systems. Modal analysis. 3 lectures, 1 laboratory.

**CE 413. Advanced Civil Computer-Aided Site Design. 2 units**

Prerequisite: BRAE 239; CE 113 or CM 115; and CE 321.

Apply advanced CAD software to develop design techniques and convey the completed design on a set of plans; site coordination, basic road design, grading, and utility design. 2 laboratories.

**CE 415. Advanced Building Information Modeling for Civil Engineering. 2 units**

Prerequisite: CE 355 and CE/CM 371. Recommended: CM 280.

Building Information Modeling (BIM) approach to design, optimize, construct, and manage vertical structures. BIM based quantity take-off, clash detection, 4D modeling, and reality capturing using 3D laser scanner. 2 laboratories.

**CE 421. Traffic Engineering. 4 units**

Prerequisite: CE 321.

Principles of traffic circulation on highway systems and other modes. Traffic control. Traffic data collection and analysis. Capacity analysis. Traffic modeling. New technologies. 3 lectures, 1 laboratory.

**CE 422. Highway Geometrics and Design. 4 units**

Prerequisite: CE 321.

Alignment location and safe geometric design of highways. Earthwork and drainage related to highway. Theory and practice in design of alignments, highway cross-sections, intersections, interchanges, and freeways in urban and rural areas. Application of advanced computer software to highway geometrics. 2 lectures, 2 laboratories.

**CE 423. Intelligent Transportation Systems. 4 units**

Prerequisite: CE 321 or graduate standing.

Specification and operation of Intelligent Transportation Systems (ITS). Traffic surveillance and control systems including applications to freeways, urban streets, rural highways, and public transportation. Standards include the National Architecture for ITS. 3 lectures, 1 laboratory.

**CE 424. Public Transportation. 4 units**

Prerequisite: CE 321.

Interdisciplinary aspects of public transportation problems, systems-team design approach to solutions. History and present state of public transportation; role of public transportation in urban environment; legislative, political, social, and economic aspects of public transportation systems. Methodology and procedures for transit planning. Review of transit studies. 3 lectures, 1 laboratory.

**CE 425. Introduction to Railway Engineering. 4 units**

Prerequisite: CE 321, and CE 381.

Introduction to railroad and railway system analysis and design. Railroads, rail transit and high speed rail applications. Track foundation design for various conditions. Approaches to railway analysis and design and an introduction to railway traffic control and signaling. 4 lectures.

**CE 429. Highway Pavement Designs. 4 units**

Prerequisite: CE 259 or CM 113; CE 381 or ARCE 421; and CE 321.

Theories, principles, and procedures in the structural design of highway pavements. Design of flexible and rigid pavements. Performance of flexible and rigid pavements in the field and the characterization of pavement materials. Practical and direct exposure to laboratory testing of pavement materials. 3 lectures, 1 laboratory. Formerly CE 521.

**CE 431. Coastal Hydraulics I. 4 units**

Prerequisite: ME 341 or ENVE 264.

Waves and their characteristics, types of waves, water wave theories, orbital velocities, refraction of waves, wave diffraction, wave reflection, application of linear theory to wave forces on cylindrical structures, submerged pipelines and vertical flat barriers (sea walls), wave uprush, rubble mound breakwaters. 4 lectures.

**CE 432. Coastal Hydraulics II. 4 units**

Prerequisite: CE 431.

Reformed breaker height determination, wave runup analysis using a reformed breaker height. Wave setback analysis. Pile height determination. Criteria for types of breaking waves. Revetment analysis, rip-rap revetment design, wave forces on pilings. 4 lectures.

**CE 433. Open Channel Hydraulics. 4 units**

Prerequisite: CE 336.

Analysis and characteristics of flow in open channels; critical flows; uniform flow; gradually varied flow; channel design problems, channel transitions and controls. Rapidly varied flow; hydraulic jump and energy dissipaters. Unsteady flows, waves and wave propagation, flood routing. Applications of numerical methods in hydraulic engineering. 4 lectures.

**CE 434. Groundwater Hydraulics and Hydrology. 4 units**

Prerequisite: CE 336.

Differential equations of groundwater flow, Darcy's Law, solutions of the steady and unsteady flow, differential equations for confined and unconfined flows. Pumping test design. Groundwater models, leaky aquifers. Saltwater intrusion. 4 lectures.

**CE 435. Engineering Hydrology. 4 units**

Prerequisite: CE 336.

Analysis of hydrologic cycle components such as precipitation, infiltration and evaporation. Rainfall-runoff analysis to determine peak flows and runoff hydrographs. Hydrologic river and reservoir routings and their applications for flood plain management. Application of frequency analysis methods to determine design rainfalls and design flows. 4 lectures.

**CE 436. Heavy Civil Temporary Structures and Shoring. 4 units**

Prerequisite: ARCE 315 or CE 352; and CM 314.

Design and construction of retaining walls, concrete formwork, falsework, scaffolding, ramps, platform, bracing, and guying as applied to heavy civil projects. Field trip may be required. 2 lectures, 2 laboratories. Crosslisted as CE/CM 436.

**CE 437. Heavy Civil Projects and Equipment. 4 units**

Prerequisite: CM 314.

Heavy civil projects logistics, construction, operations, planning, management, workflow and sequencing, equipment management, fleet configuration and maintenance, equipment productivity and cost optimization. 2 lectures, 2 laboratories. Crosslisted as CE/CM 437.

**CE 440. Hydraulic Systems Engineering. 4 units**

Prerequisite: CE 336.

Water and wastewater flows. Design of water distribution systems, transmission and storage reservoirs, wastewater collection systems, and storm water systems. Pumps and pump systems, flow measurements. Water sources for municipal supply. 3 lectures, 1 laboratory.

**CE 454. Integrated Structural Design. 4 units**

Prerequisite: CE 355, CE 356, and CE 455.

Structural analysis and integrated system design of reinforced concrete, concrete block masonry, structural steel, and timber structures. Loading standards, code design methods, connection design. Comprehensive design projects. 2 lectures, 2 laboratories.

**CE 455. Design of Timber Structures. 4 units**

Prerequisite: CE 352.

Analysis and design of timber structures with emphasis on construction methodology, and material behavior. Topics include physical and mechanical properties of structural lumber and glued laminated timber; lateral load paths; diaphragms; connections; shear wall design; and combined load design. 3 lectures, 1 activity.

**CE 457. Bridge Engineering. 4 units**

Prerequisite: CE 355. Corequisite: CE 356.

Fundamentals of the structural analysis and design of highway bridges. Construction materials in bridges. Loads on highway bridges. Load path and distribution in bridge superstructure. Design of reinforced concrete, pre-stressed concrete, and composite bridges. 3 lectures, 1 laboratory.

**CE 458. Fiber Reinforced Polymer (FRP) Design. 4 units**

Prerequisite: CE 355. Concurrent: CE 356.

Properties and mechanical characteristics of Fiber Reinforced Polymer (FRP) composite materials; applications in civil engineering structures as primary or secondary reinforcement; and design techniques based on newly developed ACI 440 design guidelines and worldwide experience in FRP design. Not open to students with credit in CE 558. 3 lectures, 1 laboratory.

**CE 459. FRP Strengthening of Reinforced Concrete Structures. 4 units**

Prerequisite: CE 355.

Flexural and shear strengthening reinforced and prestressed concrete members using fiber reinforced polymer composite plates and laminates; seismic repair and rehabilitation of columns, slabs, beams and structures. Focus on design philosophy and design methodology, based on the current understanding of FRP-strengthening techniques. Not open to students with credit in CE 556. 3 lectures, 1 laboratory.

**CE 465. Civil Engineering Professional Practice. 1 unit**

Prerequisite: Senior standing and consent of instructor.

Advising for Senior Design Project and examination of the non-technical and professional issues engineering design professionals regularly encounter. Topics include: communications styles and assertiveness, technical communications (oral and written), lifelong learning, contemporary civil engineering issues, leadership, ethics, and personal and project management. 1 activity.

**CE 466. Senior Design Project I. 3 units**

Prerequisite: CE 321, CE 322, CE 336, CE 337, CE 355, CE 381, CE 382, CE 465, and consent of instructor.

Work on multi-disciplinary teams to complete an integrated civil design project. Focus on formal instruction, through project based learning, on selected topics in geotechnical, structural, transportation, and water resources engineering design. Non-technical topics include team building, technical communications, and professional practice skills that must be mastered to become a successful design professional. 2 lectures, 1 laboratory.

**CE 467. Senior Design Project II. 3 units**

Prerequisite: CE 466.

Continuation of work on multi-disciplinary teams to complete an integrated civil design project started in CE 466. Focus of formal instruction on selected topics in geotechnical, structural, transportation, and water resources engineering design culminating with oral and written presentations of Senior Design projects. 2 lectures, 1 laboratory.

**CE 468. Community Engineering Senior Design Project I. 3 units**

Prerequisite: CE 321, CE 322, CE 336, CE 337, CE 355, CE 381, CE 382 and CE 465.

Two-part series. Student teams work in cooperation with a local community organization to complete an integrated civil design project. Projects representative of those encountered in professional practice. Focus on professional as well as design issues. Volunteer service required. 2 lectures, 1 laboratory.

**CE 469. Community Engineering Senior Design Project II. 3 units**

Prerequisite: CE 468.

Two-part series. Student teams work in cooperation with a local community organization to complete an integrated civil design project. Projects representative of those encountered in professional practice. Focus on professional as well as design issues. Volunteer service required. 2 lectures, 1 laboratory.

**CE 470. Selected Advanced Topics. 1-4 units**

Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

**CE 471. Selected Advanced Laboratory. 1-4 units**

Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

**CE 474. Environmental Compliance and Permitting. 2 units**

Prerequisite: Senior standing.

Fundamentals of State and Federal environmental laws essential to getting Civil Engineering projects permitted. 2 lectures.

**CE 475. Civil Infrastructure and Building Systems. 4 units**

Prerequisite: Senior standing in CE or ARCE.

Principles and practices for the sustainable design, fabrication, and installation of systems for the civil infrastructure and building; including structural, air/gas, water/wastewater, electrical, and control systems. Methods and materials used for fabrication and installation; including cost and schedule considerations. 4 lectures. Crosslisted as ARCE/CE 475.

**CE 481. Analysis and Design of Shallow Foundations. 4 units**

Prerequisite: CE 381 and CE 382.

Evaluation of shear strength for foundation design. Analysis of bearing capacity for generalized conditions. Design of reinforced concrete spread footings. Stress distributions beneath loaded areas. Immediate settlement, consolidation settlement, rate of consolidation, and creep. 4 lectures.

**CE 486. Introduction to Geological Engineering. 4 units**

Prerequisite: CE 381, CE 382, and GEOL 201.

Identification and characterization of consolidated geologic materials for the purpose of civil analysis and design. Interpretation of geologic maps, cross sections, and reports. Interpretation of aerial photographs. Engineering considerations important in dealing with transported soils. 4 lectures.

**CE 487. Design of Foundations and Slopes in Rock. 4 units**

Prerequisite: CE 381, CE 382, and GEOL 201.

Evaluation of the engineering properties of rocks. Rock core description. Slope stability analyses in rock. Discontinuity analysis. Rockfall hazard assessment and mitigation. Design of shallow foundations on rock. 4 lectures.

**CE 488. Engineering Risk Analysis. 4 units**

Prerequisite: Senior standing and STAT 312; or graduate standing.

Introduction to the basic concepts of probability theory, statistics, and decision theory as they pertain to problems in civil and environmental engineering. Emphasis placed on the use of probabilistic modeling, Bayesian statistics, risk analysis, and decision theory. 4 lectures.

**CE 493. Cooperative Education Experience. 2 units**

CR/NC

Prerequisite: Sophomore standing and consent of instructor.

Part-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 6 units.

**CE 494. Cooperative Education Experience. 6 units**

CR/NC

Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 18 units.

**CE 495. Cooperative Education Experience. 12 units**

CR/NC

Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A more fully developed formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

**CE 500. Individual Study. 1-3 units**

Prerequisite: Consent of department chair, graduate advisor and supervising faculty member.

Advanced study planned and completed under the direction of a member of the department faculty. Open only to graduate students who have demonstrated ability to do independent work. Enrollment by petition. Total credit limited to 4 units.

**CE 501. Advanced Matrix Analysis of Structures. 4 units**

Prerequisite: CE 406.

Matrix terminology and operations. Matrix procedures for analysis of two-dimensional frameworks. Development of stiffness, flexibility and mixed methods. Development of algorithms and programs for use in the analysis of structural frameworks. Discussion of modeling issues and limitations. 3 lectures, 1 laboratory.

**CE 504. Finite Element Analysis. 4 units**

Prerequisite: CE/ME 404 and CE 511/ME 501 or consent of instructor.

Finite element theory and application with a focus on computer implementation of the method. Strong, weak and variational formulations, physical and isoparametric spaces, error estimates, numerical integration, finite element algorithms, and programming architecture. 3 lectures, 1 laboratory. Crosslisted as CE/ME 504.

**CE 511. Continuum Mechanics and Elasticity. 4 units**

Prerequisite: Graduate standing.

Introduction to continuum mechanics. Kinematics, stress, and balance laws. Constitutive theory for isotropic and anisotropic solids and viscous fluids. Applications including design of beams and pressure vessels, stress concentrations, fiber-reinforced composites, and non-homogeneous biological materials. 4 lectures. Crosslisted as CE 511/ME 501.

**CE 513. Inelastic Stress Analysis. 4 units**

Prerequisite: ME 501 or CE 511.

Perfectly plastic and work hardening materials; von Mises and Tresca yield, isotropic and kinematic hardening flow rules, boundary-value problems. Finite elasticity: kinematics, Cauchy- and Green-elasticity, invariance, constraints, Neo-Hookean and Mooney-Rivlin materials, experimental approaches, non-uniqueness, anisotropy, residual stress, thermoelasticity, boundary-value problems. 4 lectures. Crosslisted as CE 513/ME 503.

**CE 523. Transportation Systems Planning. 4 units**

Prerequisite: CE 321 or graduate standing.

Planning of urban and regional multimodal transportation systems. Modeling of transportation networks and travel demand. Travel survey design. Urban data systems. Evaluation of alternatives based on economic, social, technological, and other factors. 2 lectures, 2 laboratories.

**CE 524. Pavement Performance and Management Systems. 4 units**

Prerequisite: CE 322 and CE 429, or graduate standing.

Introduction to pavement management; pavement distress data collection; deflection measurements and analysis; pavement performance modeling; pavement structure design; maintenance planning and rehabilitation strategies; prioritization and optimization; computer applications in pavement management. 2 lectures, 2 laboratories.

**CE 525. Airport Planning and Design. 4 units**

Prerequisite: CE 321 or graduate standing.

Historical background of aviation and airport development; financing; estimating demand; aircraft characteristics; airport capacity; airspace and air traffic control; site selection; airport configuration; geometric design of landing area; planning and development of terminal areas; lighting; pavement design and drainage. 3 lectures, 1 laboratory.

**CE 526. Transportation Safety. 4 units**

Prerequisite: CE 321, CE 322, STAT 312.

Introduction to nature and extent of transportation safety problem worldwide and in the United States. Several sub-areas of transportation safety: road safety, human factors, vehicle safety; crash data collection and management; safety planning; hot spot identification; methodologies for conducting transportation accident studies; statistical applications to accident data; predictive model building; 'before-after' studies; countermeasure design. 3 lectures, 1 laboratory.

**CE 527. Sustainable Mobility. 4 units**

Prerequisite: CE 321 or CRP 435 or consent of instructor.

Presentation and analysis of concepts and designs for sustainable mobility from a global-to-local, interdisciplinary perspective, including pedestrians, bicyclists, and public transportation. Addresses economy, environment, and equity (social issues) through lectures, panels, excursions and a planning/design project in San Luis Obispo County. 3 lectures, 1 laboratory.

**CE 528. Transportation Economics and Analysis. 4 units**

Prerequisite: CE 321 or graduate standing.

Principles of engineering systems analysis and applications to transportation using examples from different modes. Identification of transportation benefits, costs, user and non-user impacts, transportation cost models, pricing, and optimization. 3 lectures, 1 laboratory.

**CE 529. Modeling and Simulation in Transportation. 4 units**

Prerequisite: CE 321 or graduate standing.

Theory and operation of transportation systems, the systems approach, simulation techniques. Use of available software packages. Simulation model development, calibration and use. 2 lectures, 2 laboratories.

**CE 533. Advanced Water Resources Engineering. 4 units**

Prerequisite: CE 336 or graduate standing.

Matrix and simulation methods in hydrology, statistical studies in hydrology and their applications to civil engineering problems. Generalized hydrologic characteristics. Hydrologic simulation, computer applications, urban and small watershed hydrology, macroscopic and microscopic approach. Storm water management models. Hydrologic design. 4 lectures.

**CE 535. Water Resources Systems Planning and Analysis. 4 units**

Prerequisite: CE 336 or graduate standing.

Water resources planning, development, system analysis and optimization. Dynamic programming, multi-objective water resource systems. 4 lectures.

**CE 536. Computer Applications in Water Resources with Geographic Info Systems (GIS). 4 units**

Prerequisite: CE 336 or graduate standing.

Modeling, design and analysis of water, wastewater, stormwater systems. Integration of water resource systems with Geographic Information Systems (GIS). 3 lectures, 1 laboratory.

**CE 537. Groundwater Contamination. 4 units**

Prerequisite: CE 434. Corequisite: ENVE 331.

Sources and types of groundwater contamination, contamination transport mechanisms. Sorption and other chemical reactions. Numerical modeling of contaminant transport. Nonaqueous phase liquids. Groundwater remediation and design. 4 lectures.



**CE 538. Urban Water Systems. 4 units**

Prerequisite: CE 440 or graduate standing.

Integration of water delivery, wastewater collection, drainage systems, and associated treatment components in urbanizing areas. Relationships between surface and groundwater elements of water sources and disposal. Use of current design models to quantify the benefits of non-traditional options. 4 lectures.

**CE 539. Environmental Hydraulics. 4 units**

Prerequisite: CE 336 or graduate standing.

Application of fluid mechanics principles to environmental flows. Emphasis on advection, dispersion, stratification and mixing effects. Stratified flows, turbulent jets and plumes, wastewater and thermal diffusers, cooling ponds and channels, control of environmental problems. 4 lectures.

**CE 552. Analysis and Seismic Design of Reinforced Concrete. 4 units**

Prerequisite: CE 454. Recommended: Concurrent enrollment in CE 557.

Emphasis placed on reinforced concrete behavior and seismic design. Topics include moment curvature analysis and plastic hinge modeling, strut and tie, design of structural walls, design of concrete moment frames and seismic detailing. 4 lectures.

**CE 553. Ductile Design of Steel Structures. 4 units**

Prerequisite: CE 356 and senior or graduate standing. Recommended: CE 454 and CE 407.

Plastic analysis and capacity design principle; design of ductile steel structures including moment frames, concentrically braced frames, eccentrically braced frames, buckling-restrained braced frames, and steel plate shear walls according to the AISC Seismic Provisions for Structural Steel Buildings. 3 lectures, 1 activity.

**CE 555. Advanced Civil Engineering Materials Laboratory. 2 units**

Prerequisite: CE 259 or graduate standing.

Fundamental properties of new and advanced materials. Experimental techniques. Fracture characteristics and composite response of cement matrix composites. New materials and products to advanced applications such as automation. 2 laboratories.

**CE 556. Advanced Fiber Reinforced Polymer (FRP) Strengthening of Reinforced Concrete Structures. 4 units**

Prerequisite: CE 355.

Flexural and shear strengthening reinforced and pre-stressed concrete members using FRP composite laminates and plates; seismic repair and rehabilitation of columns, beams, slabs and whole structures. Design philosophies based on the current ACI 440 and the most up to date research in FRP composites. Durability, fire protection and blast mitigation of structures utilizing FRP laminates. Not open to students with credit in CE 459. 3 lectures, 1 laboratory.

**CE 557. Seismic Analysis and Design. 4 units**

Prerequisite: CE 407.

Extension of the basic principles of structural dynamics to analysis of civil structures and nonstructural components to earthquake loading. Code based (ASCE/SEI 7) earthquake resistant design. 3 lectures, 1 laboratory.

**CE 558. Advanced Fiber Reinforced Polymer (FRP) Design. 4 units**

Prerequisite: CE 355.

Properties and mechanical characteristics of FRP composites and design methodologies based on the current understanding and usage of FRP composites. Applications of composite rebars in civil engineering structures as primary reinforcement. Design and analysis of reinforced concrete structures utilizing FRP rebars based on the ACI 440 design guidelines. Not open to students with credit in CE 458. 3 lectures, 1 laboratory.

**CE 559. Prestressed Concrete Design. 4 units**

Prerequisite: CE 355 or graduate standing.

Advanced analysis, design and behavior of prestressed and precast concrete elements and structures. Origin of code requirements. Detailed design of prestressed concrete components of civil engineering systems for buildings and highway construction. Creep and shrinkage of concrete and relaxation of steel applied to prestressing losses. 4 lectures.

**CE 570. Selected Advanced Topics. 1-4 units**

Prerequisite: Graduate standing or consent of instructor.

Directed group study of selected topics for advanced students. Open to graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 seminars.

**CE 571. Selected Advanced Laboratory. 1-4 units**

Prerequisite: Graduate standing or consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

**CE 581. Advanced Geotechnical Engineering. 4 units**

Prerequisite: CE 481 or graduate standing.

Advanced topics in saturated flow, unsaturated flow, and consolidation. Stress-strain-deformation response of soils under both drained and undrained loading. Conventional and advanced laboratory strength testing. 3 lectures, 1 laboratory.

**CE 583. Geotechnical Earthquake Engineering. 4 units**

Prerequisite: CE 481 or graduate standing.

Introduction to engineering seismology and ground motion evaluation. Dynamic behavior of soils. Seismic site response analysis. Soil liquefaction evaluation methods and mitigation techniques. Seismic stability of slopes and retaining walls. Computer-aided analysis. 4 lectures.

**CE 584. Lateral Support Systems. 4 units**

Prerequisite: CE 481 or graduate standing.

Classical and modern earth pressure theories. Lateral earth pressure calculations for general subsurface conditions. Analysis and design of reinforced concrete cantilever walls, sheetpile walls, soldier-pile walls, tie-back walls, and mechanically-stabilized earth. Computer-aided analysis and design. 4 lectures.

**CE 585. Slope Stability Analysis. 4 units**

Prerequisite: CE 481 or graduate standing.

Analysis of stability by planar, circular arc, piecewise-linear, and composite-surface techniques. Analysis of earth-fill dams and reservoirs for static, steady flow, sudden drawdown, and seismic loading conditions. Field instrumentation. Methods for slope remediation and stabilization. Computer-aided analysis. 4 lectures.

**CE 586. Analysis and Design of Deep Foundations. 4 units**

Prerequisite: CE 481 or graduate standing.

Bearing capacity and settlement analysis of drilled shafts and driven piles. Analysis and design of single piles and pile groups for vertical, lateral, and combined loading. Construction procedures, field inspection, and load-testing. Computer-aided analysis and design. 4 lectures.

**CE 587. Geoenvironmental Engineering. 4 units**

Prerequisite: CE 381.

Principles for containment applications. Engineering properties of soils and geosynthetics and their interaction with contaminants and wastes; analysis of geosynthetics used in containment facilities; liners; covers; leachate and gas collection systems; contaminant transport; and monitoring systems. 4 lectures.

**CE 588. Ground Improvement. 4 units**

Prerequisite: CE 381, CE 382, and CE 481.

Ground improvement applications investigated for modification of geomechanical and hydraulic properties of soils. Engineering properties of soft ground and high water content materials; mechanical, chemical, and thermal stabilization investigated for foundation and environmental remediation applications. 4 lectures.

**CE 589. Geosynthetics Engineering. 4 units**

Prerequisite: CE 481.

Geosynthetics applications within civil engineering. Design content for geotechnical, geoenvironmental, and transportation applications. Manufacturing processes, material properties, interaction with soils, and service conditions. 4 lectures.

**CE 591. Graduate Seminar I. 1 unit**

Prerequisite: Graduate standing.

Preparation for graduate studies and engineering careers. Further development of oral and written communication skills. 1 seminar.

**CE 592. Graduate Seminar II. 1 unit**

Prerequisite: CE 591 and graduate standing.

Current research activities and analysis/design philosophies in civil and environmental engineering practice. Development of oral and written presentation skills. 1 seminar.

**CE 593. Cooperative Education Experience. 2 units**

CR/NC

Prerequisite: Graduate standing and consent of instructor.

Advanced study analysis and part-time work experience in student's career field; current innovations, practices, and problems in administration, supervision, and organization of business, industry, and government. Must have demonstrated ability to do independent work and research in career field. Credit/No Credit grading only.

**CE 594. Cooperative Education Experience. 6 units**

CR/NC

Prerequisite: Graduate standing and consent of instructor.

Advanced study analysis and full-time work experience in student's career field; current innovations, practices, and problems in administration, supervision, and organization of business, industry, and government. Must have demonstrated ability to do independent work and research in career field. Credit/No Credit grading only.

**CE 595. Cooperative Education Experience. 12 units**

CR/NC

Prerequisite: Graduate standing and consent of instructor.

Advanced study analysis and full-time work experience in student's career field; current innovations, practices, and problems in administration, supervision, and organization of business, industry, and government. Must have demonstrated ability to do independent work and research in career field. A fully-developed formal report and evaluation by work supervisor required. Credit/No Credit grading only.

**CE 596. Comprehensive Examination. 1 unit**

CR/NC

Prerequisite: Graduate standing. Recommended: Student should be in the final quarter of completing graduate coursework (45 units of 400 and 500 level coursework) and prepared to take the MS exam.

Comprehensive exam for a non-thesis master's student. The comprehensive examination assesses the student's ability to integrate knowledge, show critical and independent thinking, and demonstrate mastery of the subject matter. Timing of the comprehensive exam shall be scheduled with the faculty advisor per department guidelines.

**CE 599. Design Project (Thesis). 1-9 units**

Prerequisite: Graduate standing.

Each individual or group will be assigned a project for solution under faculty supervision as a requirement for the master's degree, culminating in a written report/thesis.

**ENVE Courses****ENVE 111. Introduction to the Environmental Engineering Profession. 1 unit**

CR/NC

Introduction to the Environmental Engineering Program including course planning, opportunities for global and regional problems such as water quality, waste management, and sustainability. Credit/No Credit grading only. 1 activity.

**ENVE 264. Environmental Fluid Mechanics. 4 units**

Prerequisite: MATH 241, PHYS 132, and ME 211.

Theory and application of fluid statics and fluid dynamics to environmental problems in air and water systems. Fluid properties, pressure within stationary and moving systems, fluid momentum, pipe and channel flow including Bernoulli's Equation and friction effects, flow measurement systems. 4 lectures.

**ENVE 270. Selected Topics. 1-4 units**

Prerequisite: Open to undergraduate students and consent of instructor.

Directed group study of selected topics. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

**ENVE 304. Process Thermodynamics. 3 units**

Corequisite: CHEM 125 or CHEM 129; ENVE 331.

First and second laws of thermodynamics, properties of gases, liquids and mixtures, vapor-liquid equilibria, solubility and absorption, equilibrium in chemical reactions, thermodynamic applications in environmental engineering. 3 lectures.

**ENVE 309. Noise and Vibration Control. 3 units**

Prerequisite: MATH 241 and PHYS 132. Corequisite: ENGL 149.

Impact of noise and methods for noise reduction in industrial environments. Behavior of sound waves, selection of instrumentation, practical measurements, criteria for noise and vibration control. Laboratory and field measurements to investigate the basic principles of sound propagation and control. Assessment of noise produced by transportation and other engineering facilities. 2 lectures, 1 laboratory.

**ENVE 323. Engineering for the Environment. 4 units**

2020-21 or later: Upper-Div GE Area B

2019-20 catalog: GE Area B7

2017-19 or earlier catalog: GE Area F

Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

Societal importance of air quality, water quality and land resources. Technologies used to control air and water pollution and the scientific basis for these technologies. Use of mass balances to understand pollutant transport and treatment. Local examples of the application of pollution control technologies to meet legal requirements. Not for engineering majors. 4 lectures. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).

**ENVE 324. Introduction to Air Pollution. 4 units**

2020-21 or later: Upper-Div GE Area B

2019-20 catalog: GE Area B7

2017-19 or earlier catalog: GE Area F

Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

Causes and effects of air pollution on the individual, the community and industry. Application of mathematics and chemistry to solve air pollution problems. For non-majors. 4 lectures. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).

**ENVE 325. Air Quality Engineering. 4 units**

Prerequisite: CHEM 125 or CHEM 128.

Causes and effects of air pollution on individual, regional, and global scales including meteorology, pollutant chemistry, global and regional transport, health impacts, regulations, air pollution control technology, and global climate change. Engineering principles to understand, model, and predict air quality. 4 lectures.

**ENVE 331. Fundamentals of Environmental Engineering. 4 units**

Prerequisite: CHEM 125 or CHEM 128, MATH 242 or MATH 244 (or concurrent).

Description and quantification of water and air quality characteristics important for water and wastewater treatment and air pollution control. Fundamentals of kinetics, reactor configurations, toxicity and dose-response relationship. Regulations governing ambient pollutant levels and discharges. Introduction to the modeling of pollutant fate and transport. Overview of solid waste management and global environmental issues. 4 lectures.

**ENVE 400. Special Problems. 1-2 units**

Prerequisite: Consent of department chair.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**ENVE 405. Environmental Engineering Research. 1-2 units**

Prerequisite: Junior standing and consent of instructor. Recommended: Prior or concurrent enrollment in ENVE 434 and ENVE 438.

Participation in environmental engineering research projects with emphasis on professional safety procedures for lab and field work and data quality assurance/quality control. Research projects focus on developing technologies or techniques that improve the sustainability of environmental engineering infrastructure. Total credit limited to 8 units; technical elective credit limited to 4 units. 1 laboratory.

**ENVE 407. Environmental Engineering Design Competition. 1 unit**

Prerequisite: consent of instructor. Recommended: ENVE 331.

Design, build, test, and present a solution to an environmental problem posed by a student design competition. 1 laboratory. Total credit limited to 4 units.

**ENVE 411. Air Pollution Control. 4 units**

Prerequisite: CE 251 or CSC 231; ENVE 304 or ME 302; ENVE 264 or ME 341; ENVE 325; and ENVE 331.

Theory, principles, and practices related to the control of particulate and gaseous emissions. Mechanical and chemical separations. Cost and design of control systems. 4 lectures.

**ENVE 421. Mass Transfer Operations. 4 units**

Prerequisite: ENVE 325, ENVE 331, ENVE 304 or ME 302, ENVE 264 or ME 341.

Theory of mass transfer principles applied to environmental problems. Diffusion and dispersion modeling of contaminant transport. Design principles of scrubbers, absorbers, and membrane systems for air and water pollution control. 4 lectures.

**ENVE 426. Air Quality Measurements. 3 units**

Prerequisite: ENVE 325, CHEM 212/312, ENVE 264 or ME 341, STAT 312, and ENGL 149.

Planning and conducting air quality measurements in the atmosphere, indoors and at the source. Topics include quality control, calibration, and instrument operation for particulate matter, gas and meteorological measurements. 2 lectures, 1 laboratory.

**ENVE 434. Water Chemistry and Water Quality Measurements. 4 units**

Prerequisite: CHEM 125 or CHEM 129, ENVE 330 or ENVE 331.

Aquatic environmental chemistry and water quality measurements. Equilibrium chemistry, carbonate systems, redox reactions, and electrochemistry. Laboratories include topics such as measurement of suspended solids, turbidity, alkalinity, BOD, and coliform detection. Quality analysis and control. 3 lectures, 1 laboratory.

**ENVE 436. Introduction to Hazardous Waste Management. 4 units**

Prerequisite: ENVE 325 and ENVE 331.

Overview of hazardous waste generation, federal and state regulations, storage, transport, treatment, and remediation. Principles of toxicology, unit operations and processes for the treatment, reduction, and remediation of wastes. Ultimate disposal including incineration, solidification, and bioremediation 4 lectures.

**ENVE 438. Water and Wastewater Treatment Design. 3 units**

Prerequisite: ENVE 331 and ME 341 or ENVE 264.

Theory and design of facilities for physical and chemical treatment of water and wastewater, biological treatment of wastewater, and treatment and disposal of sludge. 3 lectures.

**ENVE 439. Sustainable Solid Waste Engineering. 4 units**

Prerequisite: ENVE 325 and ENVE 331; or graduate standing.

Design and analysis of recycling, composting, anaerobic digestion, gasification, and combustion systems for the recovery of resources and energy from solid wastes. Field trips required. 3 lectures, 1 laboratory.

**ENVE 443. Bioremediation Engineering. 4 units**

Prerequisite: ENVE 331.

State-of-the-art bioremediation technologies for soil, groundwater and contaminated air stream remediation and pollution prevention. Introduction to engineering design combining biogenetics, reactor configuration, and basic biological and engineering principles. Various in-situ and ex-situ technologies. Field trip may be required. 3 lectures, 1 laboratory.

**ENVE 450. Industrial Pollution Prevention. 4 units**

Prerequisite: ENVE 331.

Theory and case studies of innovative industrial waste minimization and resource conservation through principles of pollution prevention. Life-cycle assessment, pollution prevention, economic analysis, and sustainable designs. 3 lectures, 1 laboratory.

**ENVE 455. Environmental Health and Safety. 4 units**

Prerequisite: ENVE 331.

Physical, chemical and biological hazards associated with industrial processes. Toxicology. Safety analysis and design. Causes and prevention of occupational and environmental hazards. Development and implementation of industrial hygiene programs. 4 lectures.

**ENVE 466. Senior Project Design Laboratory I. 2 units**

Prerequisite: ENVE 438, CE 336 and senior standing. Corequisite: CE 465.

Capstone team project on a complex, integrated design problem typical of the environmental engineering profession. Formal reports and presentations are prepared. Non-technical issues addressed: ethics, teamwork, leadership, communication, and professional practice. 2 laboratories.

**ENVE 467. Senior Project Design Laboratory II. 2 units**

Prerequisite: ENVE 466.

Continuation of ENVE 466. Continuation of capstone project by individuals or teams with submission of final reports and presentations 2 laboratories.

**ENVE 470. Selected Advanced Topics. 1-4 units**

Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

**ENVE 471. Selected Advanced Laboratory. 1-4 units**

Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

**ENVE 480. Environmental Engineering of Energy. 4 units**

Prerequisite: ENVE 304 or ME 302; ENVE 331. Recommended: ENVE 325.

Environmental impacts of conventional and renewable energy production and of emerging renewable energy development. Environmental engineering methods for mitigation of impacts of fossil fuel processing, including hydrofracking. Greenhouse gas inventory and management. Field trips required. 3 lectures, 1 laboratory.

**ENVE 490. Environmental Nanotechnology. 4 units**

Prerequisite: ENVE 331 or MATE 370; and CHEM 125. Recommended: ENVE 421.

Nanotechnology basics, unique properties of nanomaterials, synthesis and characterization of nanomaterials from an environmental life-cycle perspective, environmental remediation using nanomaterials, environmental fate, transport, and toxicity of nanomaterials, sustainable nanotechnology, nanotechnology ethics and regulations, and careers in nanotechnology. 3 lectures, 1 laboratory.

**ENVE 495. Cooperative Education Experience. 12 units**

CR/NC

Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A more fully developed formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

**ENVE 500. Individual Study. 1-3 units**

Prerequisite: Graduate standing and consent of department chair.

Advanced study planned and completed under the direction of a member of the department faculty. Open only to graduate students who have demonstrated ability to do independent work. Total credit limited to 4 units.

**ENVE 525. Indoor Air Quality Engineering. 4 units**

Prerequisite: ENVE 264 or ME 341; senior or graduate standing.

Recommended: ENVE 325.

Pollutants sources and sinks indoors, transport processes, ventilation, and engineering controls. Human factors and engineering factors that influence the quality of the indoor environment. 4 lectures.

**ENVE 535. Physico-Chemical Water and Wastewater Treatment. 4 units**

Prerequisite: Graduate standing or consent of instructor.

Physical and chemical processes used in potable water treatment and advanced wastewater treatment. Coagulation, flocculation, sedimentation, filtration, membrane separation, disinfection, and absorption. Wastewater recycling regulations. Integration of treatment processes. 4 lectures.

**ENVE 536. Biological Wastewater Treatment Processes Engineering. 4 units**

Prerequisite: Graduate standing or consent of instructor.

Fundamentals of biological wastewater treatment. Suspended and attached growth bioreactors. Activated sludge, biotower, and anaerobic process design. Biological nutrient removal. 4 lectures.

**ENVE 537. Decentralized Wastewater Management. 4 units**

Prerequisite: ENVE 438 or Graduate standing.

Design and management of decentralized wastewater treatment systems. Septic tanks, aerobic nutrient removal systems, ponds, constructed wetlands, and improved latrines; surface and subsurface effluent recycling or disposal; and septage management. 4 lectures.

**ENVE 542. Sustainable Environmental Engineering. 4 units**

Prerequisite: Graduate or senior standing or consent of instructor.

Critical analysis of environmental engineering practices such as solid waste management, recycling, and wastewater treatment from the viewpoint of energy efficiency, lifecycle cost, and sustainability. Both laboratory experiments and computer models to assess sustainability. 3 lectures, 1 laboratory.

**ENVE 570. Selected Advanced Topics. 1-4 units**

Prerequisite: Graduate standing or consent of instructor.

Directed group study of selected topics for advanced students. Open to graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1-4 seminars.

**ENVE 571. Selected Advanced Laboratory. 1-4 units**

Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

**ENVE 581. Biochemical Engineering. 4 units**

Prerequisite: CHEM 312 and MCRO 221.

Types of microorganisms and microbially-mediated biochemical reactions for biotechnology applications. Stoichiometric and thermodynamic principles for microbial growth and metabolism. Material and energy balances for aerobic and anaerobic growth and bioreactor design. Kinetics of enzyme catalyzed reactions. Field trips required. 3 seminars, 1 laboratory. Crosslisted as ENGR/ENVE 581.

**ENVE 599. Design Project (Thesis). 1-9 units**

Prerequisite: Graduate standing.

Each individual or group will be assigned a project for solution under faculty supervision as a requirement for the master's degree, culminating in a written report/thesis.