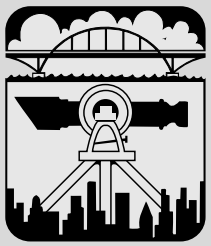
engineering — civil



bachelor of science ■ master of science

Program Description

Civil Engineering involves the application of scientific principles and knowledge of mathematics and computers to the planning, analysis, design and construction of all types of private and public works. Reduction of air and water pollution, disposal of hazardous wastes, renewal of our old cities, planning and building of new communities, providing water, power, and high-speed ground transportation systems are the responsibilities of the civil engineer. It is a continual challenge to the civil engineer to provide these services efficiently by the construction of dams, buildings, bridges, tunnels, highways, airports, waterways, and waste handling facilities in harmony with the natural environment.

Because of the broad range of demands on the civil engineer's services, the undergraduate program is devoted to fundamental principles in mathematics; basic and engineering sciences; the spectrum of civil engineering practice in both analysis and design; and required courses in the humanities and the social sciences, so that engineers may better relate to the world and society they serve. The upper division program permits students to select 9 units (3 courses) of electives. Students may increase the breadth or depth of their knowledge in civil engineering by selecting these electives in several areas: environmental and water quality engineering, geotechnical engineering, structural engineering, transportation and water resources engineering.

Faculty

Michael Anderson, Cyrus Aryani, Keith Bisharat, Francois Cheong-Siat-Moy, Ed Dammel, Karen Hansen, Bernard Hayek, Ralph Hwang, John Johnston, Ramzi Mahmood, Eric Matsumoto, Joel Moore, Donald Nostrant, Ali Porbaha, Beverley Sheafer, Chris Tomine

Contact Information

Ramzi J. Mahmood, *Department Chair* ■ Gina Lombardo, *Administrative Support Coordinator* ■ Riverside Hall 4024 ■ (916) 278-6982 ■ *hera.ecs.csus.edu/ce*

Specializations

- **MS:** Environmental-Water Quality Engineering / Geotechnical Engineering / Structural Engineering / Transportation Engineering / Water Resources Engineering

Special Features

- The BSCE degree is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc. (EAC/ABET).
- A notable strength of the program is that most faculty are licensed professional engineers in California and have practical experience in industry. Thus, faculty bring an ability to relate theory to practice, and the program prepares the student for the profession as well as for advanced study.
- Emphasis is placed on design that is the definition and solution of engineering problems in a practical manner. Lower division, and first semester junior year course work, provides the preparation for design in courses such as mathematics, physics, descriptive geometry, CAD, surveying, computer applications, and engineering economics. Design courses are available to students in their last three semesters including a senior design project course in the final semester.
- Class sizes are small providing for close interaction between students and faculty. This interaction is enhanced in laboratory courses that are an integral part of the curriculum.

Career Possibilities

Bridge Engineer ■ Civil Engineer ■ Construction Engineer ■ Design Engineer ■ Environmental Engineer ■ Foundation Engineer ■ Geotechnical Engineer ■ Highway Engineer ■ Hydraulic Engineer ■ Hydrologic Engineer ■ Project Engineer ■ Public Works Engineer ■ Research Engineer ■ Sanitary Engineer ■ Soils Engineer ■ Structural Engineer ■ Traffic Engineer ■ Transportation Engineer ■ Urban Planner ■ Water Resources Engineer

- Computers are used in many courses and students have free access to computer laboratories.
- Communication skills and social and ethical responsibilities of professional practice are emphasized.
- Students are encouraged to participate in the Student Chapter of American Society of Civil Engineers and other student organizations, to develop organizational skills, and to interact with practicing civil engineers.
- Sacramento, the State Capital and the seat of county government, provides proximity to city, county, state and federal agencies, and many consulting firms with civil engineering departments. Thus, students have a unique environment to draw upon for semester projects, part-time or summer employment, and career opportunities.

Program Educational Objectives

The objectives of this program are to prepare graduates to:

- succeed in professional employment and/or graduate study in civil engineering;
- identify, analyze, and solve practical civil engineering problems;
- apply knowledge of Environmental, Geotechnical, Structural, Transportation, and Water Resources Engineering to design of civil engineering projects;
- communicate effectively with their peers, other professionals, decision makers, and the general public, in the conduct of their work; and
- practice civil engineering in a professionally responsible and ethical manner.

Department of Civil Engineering: Academic Policies and Procedures

The following is a summary of policies and procedures specific to the Department of Civil Engineering. Other University policies and procedures in this catalog also apply to Civil Engineering majors. The Department will not hear petitions for deviation from articulated policies made by students who disregard catalog policy.

- **Course Repeat Policy:** Undergraduate engineering and civil engineering courses that are used to meet the Bachelor of Science in Civil Engineering degree requirements may be repeated only twice (for a total of three attempts). Grades of the second and third attempt will be averaged in grade point calculations.
- **Reinstatement Policy:** Students seeking reinstatement to the Civil Engineering major must complete a Reinstatement Petition (obtained at Admissions and Records). That petition will be reviewed by the Department Chair for approval or rejection.

Note: The only basis for reinstatement is the expectation (supported by evidence provided by the student) that the student is now likely to progress towards the satisfactory completion of the Department's degree requirements in a timely manner.

- **Minimum Grade Requirements:** The purpose of this requirement is to assure that all Civil Engineering majors attain the minimum level of competency in all their course work required for a Bachelor of Science Civil Engineering Degree.
  Courses that are prerequisites to courses taken for the major and CE 009, ENGR 115, ENGR 140, ENGL 001A, and ENGL 020 must be completed with a grade of "C-" or better.
  A minimum grade point average of 2.0 ("C") is required in the major courses applied to the degree.
- **Incomplete Grades:** Incomplete grades are issued only in accordance with University policy. The student must be passing the course at the time an "Incomplete" is requested. An Incomplete Petition (obtained in the Department office) must be submitted to the Department with the student's and the course instructor's signature. The Incomplete Petition must specify the work to be completed, the basis by which the student's final grade will be determined, and the last date for completion of the incomplete work. An incomplete grade that is not cleared by the set date will lapse to an "F" grade.

Undergraduate Programs

Students must satisfy the requirements of the Accreditation Board for Engineering and Technology (EAC/ABET). Consult the Civil Engineering Department Chair for specific General Education requirements.

Courses may be interchanged between semesters to accommodate the student's schedule, as long as prerequisites are observed. **Working students should expect to take more than four years to complete the degree.**

Requirements ▪ Bachelor of Science Degree

Units required for Major: 60 plus GE courses
Units required for Pre-major: 42 plus GE courses
Minimum total units for the BS: 138

Note: Additional units may be required to meet the CSUS foreign language requirement.

Courses in parentheses are prerequisites.

A. Required Lower Division Courses (Pre-Major)

First Semester Freshman Year (17 units)

(5)	CHEM 001A *	General Chemistry I (High school algebra [two years] and high school chemistry; or equivalent)
(4)	MATH 030 *	Calculus I (MATH 029 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
(2)	ENGR 004	Engineering Graphics and CAD

(3) General Education course
(3) General Education course

Second Semester Freshman Year (17 units)

(3) CE 009 Plane and Topographic Surveying (MATH 026A or MATH 030; may be taken concurrently)
(4) MATH 031* Calculus II (MATH 030 or appropriate high school based AP credit)
(4) PHYS 011A* General Physics: Mechanics (MATH 030, MATH 031 or equivalent certificated high school courses. MATH 031 may be taken concurrently)
(3) General Education course
(3) General Education course

First Semester Sophomore Year (17 units)

(3) ENGR 045 Engineering Materials (PHYS 011A, CHEM 001A)
(4) MATH 032 Calculus III (MATH 031)
(4) PHYS 011C * General Physics: Electricity and Magnetism, Modern Physics (MATH 031, PHYS 011A)
(3) General Education course
(3) General Education course

Second Semester Sophomore Year (18 units)

(3) ENGL 020 College Composition II (ENGL 001A with a grade C- or better, or equivalent)
(3) ENGR 017 Introductory Circuit Analysis (PHYS 011C, MATH 045; either the math or physics may be taken concurrently, but not both)
(3) ENGR 030 Analytic Mechanics: Statics (ENGR 004 or ENGR 006)
(3) MATH 045 Differential Equations for Science and Engineering (MATH 031)
(3) General Education course
(3) General Education course

*Indicates course which can also be used to meet University General Education requirements.

B. Required Upper Division Courses (Major)

Students must normally complete all lower division preparation before enrolling in upper division Engineering or Civil Engineering courses.

First Semester Junior Year (18 units)

(2) CE 100 Engineering Geology (ENGR 112; may be taken concurrently)
(3) CE 101 Computer Applications in Civil Engineering (ENGR 004, ENGR 030)
(3) ENGR 110 Analytic Mechanics: Dynamics (ENGR 030, MATH 032, MATH 045)
(3) ENGR 112 Mechanics of Materials (ENGR 030, ENGR 045, MATH 045)
(2) ENGR 115 Statistics for Engineers (Corequisite: MATH 031)
(3) ENGR 140 Engineering Economics (ENGR 017, or ENGR 030, or MET 030, or instructor permission)
(3) General Education course

Second Semester Junior Year (18 units)

(1) CE 113 Structural Laboratory (ENGR 112, CE 101)
(3) CE 147* Transportation Facility Design (CE 009, and CE 101) **OR**
CE 148* Transportation Systems (ENGR 115, ENGR 140, CE 101, passing score on WPE)
(4) CE 161 Theory of Structures I (CE 101, ENGR 112, MATH 032)
(4) CE 171A Soil Mechanics (CE 100, CE 101, ENGR 112)
(3) ENGR 132 Fluid Mechanics (ENGR 110)
(3) General Education course

First Semester Senior Year (17 units)

(3) ENGR 124 Thermodynamics (MATH 032, PHYS 011A, CHEM 001A)
(1) CE 135 Hydraulics Laboratory (ENGR 132, CE 101, passing score on WPE)
(3) CE 163 Structural Design in Steel I (CE 161)
(4) CE 170 Principles of Environmental Engineering (CE 101; ENGR 140; ENGR 140 may be taken concurrently. Passing score on WPE)
(3) CE elective+
(3) General Education course

Second Semester Senior Year (16 units)

(4) CE 137 Water Resources Engineering (ENGR 115, ENGR 132, ENGR 140)
(3) CE 164 Reinforced Concrete Design (CE 161, CE 113; CE 113 may be taken concurrently)
(3) CE 190 Senior Design Project
(3) CE elective+
(3) CE elective+

+ One CE elective is restricted to a design course.

* Either CE 147 or CE 148 is required, the other may be used as an elective.

C. Civil Engineering Electives

Electives are to be chosen from the following courses in consultation with a faculty advisor and must include at least one design elective (indicated by°).

Fall

CE 138, CE 166, CE 167°, CE 168°, CE 169A°, CE 172°, CE 177, or CE 184

Spring

CE 139°, CE 146, CE 162, CE 165°, CE 169B°, CE 171B°, CE 173°, or CE 181

° Indicates a design elective.

Note: Other electives, such as CE 196 or CE 199 may be chosen with the approval of a faculty advisor and Department Chair.

Cooperative Education Program (work experience)

The Department of Civil Engineering encourages eligible students to participate in the Cooperative Education Program (Co-op). Eligibility requirements are completion of the pre-major and the first semester junior year with a minimum GPA of 2.5. The program provides alternate periods of University study and major-related, paid, off-campus work experience in private industry or government. The experience will enhance the student's employment prospects upon graduation. Participants in this program will

complete the equivalent of one or two six-month work periods in their junior year and/or their senior year. Students must enroll in the appropriate Professional Practice course (CE 195 A, B, C, or D) and are awarded a Certificate on satisfactory completion of the Co-op. However, the credits for this course do not replace the curricular requirements of the BSCE degree. Students interested in the Cooperative Education Program should apply in the satellite office in Riverside Hall 2004 or the main office in Lassen Hall 2008. For information call (916) 278-7234.

Graduate Program

Civil Engineering encompasses a broad range of professional activities. The four years of undergraduate preparation for the Bachelor of Science degree are devoted to fundamental analytical principles and basic design applications. For technical competence in specialized areas and continued effectiveness on the job, graduate study is becoming increasingly necessary.

The Civil Engineering Department offers a graduate program of study leading to a Master of Science degree in Civil Engineering in the following areas of concentration:

- **Environmental/Water Quality Engineering** - environmental quality analysis and management, water and waste treatment, control of toxic substances;
- **Geotechnical Engineering** - properties and behavior of soil and their application to practical problems, soil improvement and ground stabilization, and soil dynamics and earthquake engineering;
- **Structural Engineering** - earthquake resistant steel and concrete design applied to buildings and bridges, structural dynamics, structural mechanics and finite element methods;
- **Transportation Engineering** - traffic flow, planning theory and system management applicable to all modes with emphasis on highway and rail passenger transportation; interdisciplinary study with other areas of civil engineering as well as with non-engineering areas (e.g., Environmental Studies, Geography, Government, and Organizational Behavior and Environment) may also be arranged; and
- **Water Resources Engineering** - advanced hydraulics and modern hydrologic techniques, flood forecasting, groundwater flow modeling, water resources management and policy formulation.

Each area of concentration consists of a set of core courses, a choice of electives, and culminating requirements; all selected by the student and approved by an advisor. Practicing engineers who do not have a degree objective may choose to enroll in selected courses as part of a continuing education program.

The University has excellent computing facilities with unlimited and free access in support of its programs. Access is provided to open student laboratories with Pentium work stations. Access to mainframe computers is also available, either from remote terminals strategically located on campus or by telephone line from off-campus locations.

Graduate brochures specifically describing the program in each area are available in the Department office. Some graduate assistantships are available to qualified students. Application forms for these can be obtained from the Department or from the Office of Graduate Studies, River Front Center 206, (916) 278-6470.

Admission Requirements

Admission as a classified graduate student in Civil Engineering requires:

- an undergraduate degree in Civil Engineering; and
- a minimum 2.8 GPA both overall and in upper division engineering courses.

In addition, the merit of past academic endeavor, potential for future study, and professional goals may also be considered for granting admission.

Applicants who have deficiencies in admission requirements that can be removed by specified additional preparation may be admitted with conditionally classified graduate status. Any deficiencies will be noted on a written response to the student's admission application.

Students with a baccalaureate degree in engineering majors other than Civil Engineering (e.g., Electrical and Electronic, Industrial, Mechanical, or Surveying) or in other non-engineering scientific disciplines (e.g., Mathematics, Physics, or Geology) who wish to pursue the graduate program in Civil Engineering may be considered on an individual basis. Such students may be admitted as conditionally classified students and will be required to complete a specifically designed list of undergraduate prerequisite courses in engineering and/or mathematics, physics, and chemistry to correct undergraduate deficiencies. Such a student must have an approved study program on file with the Department while undertaking this qualifying work. On completion of these courses with a GPA of 2.8 or better, the student may apply for classified graduate status in Civil Engineering.

Admission Procedures

Applications may be accepted as long as room for new students exists. However, students are strongly urged to apply by April 1 for the following fall or October 1 for the following spring, in order to allow time for Computer Access to Student Personal and Enrollment Records (CASPER) deadlines. All prospective graduate students, including CSUS graduates, must file the following with the Office of Graduate Studies:

- an online application for admission; and
- two sets of official transcripts from all colleges and universities attended, *other than CSUS.*

Approximately six weeks after receipt of all items listed above, a decision regarding admission will be mailed to the applicant. After being admitted, students must meet with an advisor and complete a Graduate Student Advising Form (obtainable in the Civil Engineering Department). This advising form must be kept current and on file in the Department office.

Advancement to Candidacy

Each student must file an application for Advancement to Candidacy, indicating a proposed program of graduate study. This procedure should begin as soon as the graduate student has:

- removed any deficiencies in admission requirements;
- obtained classified graduate status;
- completed at least 12 units in the graduate program with a minimum 3.0 GPA, including at least three courses at the 200-level;
- passed the Writing Proficiency Examination (WPE) or secured approval for a WPE waiver; and
- selected and obtained approval for a culminating requirement (Plan A, B, or C).

Advancement to Candidacy forms are available in the Department and in the Office of Graduate Studies. The student fills out the form after planning a degree program in consultation with his or her faculty advisor. The completed form is then approved by the Graduate Coordinator of the Department and submitted to the Office of Graduate Studies.

All graduate degree programs are subject to general University requirements for graduate degrees, explained in the *Graduate Studies* section of this catalog.

Requirements ▪ Master of Science Degree

Units required for the MS: 30 - Includes research or independent study and units required in area of concentration (see below)
Minimum GPA: 3.0

A. Required Course (3 units)

Select one of the following with advisor approval:

ENGR 201	Engineering Analysis I (MATH 045)
ENGR 202	Engineering Analysis II (MATH 045)
ENGR 203	Engineering Statistics (ENGR 115 or equivalent)

B. Elective Courses (6-9 units)

Elective courses (including CE 299) selected with prior approval of the student's faculty advisor in the area of interest. In addition to 200-level courses, these may also include the technical electives (but not the required courses) from the undergraduate curriculum. Not more than 3 units of CE 299 may be taken without prior approval of the Graduate Coordinator.

C. Culminating Requirement (3-6 units)

Choose one of the following CE 500 requirements:

Plan A: Master's Thesis (3-6 units)

Plan B: Master's Project (3-6 units) Approval by two faculty readers and a presentation are required. The thesis or project must comply with University standards for format and is filed in the University Library.

Plan C: Directed Study (3 units) and Comprehensive Examination (0 units). Approval of one faculty member is required for Directed Study. The comprehensive examination is administered by a committee of three faculty members.

Additional Requirements for Concentrations:

Units required: 15, with a minimum of four courses taken from one of the following five areas of concentration and additional 200 level course work (not including CE 299). Concentration is **in addition** to core requirements above.

Environmental/Water Quality Engineering
CE 250, CE 252A, CE 252B, CE 252C, CE 254, CE 255, or CE 276

Geotechnical Engineering
CE 280A, CE 280B, CE 280C, CE 283, CE 284, CE 285, or CE 286

Structural Engineering
CE 231A, CE 231B, CE 232, CE 234, CE 266, or CE 267

Transportation Engineering
CE 261, CE 262, CE 263, CE 265, or CE 285

Water Resources Engineering
CE 250, CE 251,CE 271, CE 272, CE 274, or CE 276

Lower Division Courses

CE 009. Plane and Topographic Surveying. Instruments, methods and theories necessary for the measurement of distance, direction, angles and elevations. Application of data to traverse computations, estimation of earthwork volumes, transportation facility design and construction layout. Introduction to legal aspects of surveying, geodetic surveys, maps, boundary surveys and new technologies used in surveying. Lecture two hours; laboratory three hours. **Prerequisite:** MATH 026A or MATH 030; may be taken concurrently. 3 units. (CAN ENGR 010)

Upper Division Courses

CE 100. Engineering Geology. Soil and rock mechanics and their relations to geological features influencing design, construction and maintenance of engineering projects. Lectures and field problems. **Prerequisite:** ENGR 112; may be taken concurrently. 2 units.

CE 101. Computer Applications in Civil Engineering. Develops a computer-based concept for problem solving and graphical presentation of results with applications in five areas of civil engineering: environmental, geotechnical, structural, transportation and water resources. Uses word processing, spreadsheets, structured programming (Visual BASIC with spreadsheets), and special purpose software packages. Lecture two hours; laboratory three hours. **Prerequisite:** ENGR 004, ENGR 030. 3 units.

CE 113. Structural Laboratory. Introduction to the principles of structural analysis and design by testing of structural elements. Experimental verification of the assumptions of strength of materials. Introduction to laboratory techniques. Laboratory three hours. **Prerequisite:** ENGR 112, CE 101. 1 unit.

CE 135. Hydraulics Laboratory. Laboratory experiments relating the principles of fluid mechanics to real fluid flow. Laboratory three hours. **Prerequisite:** ENGR 132, CE 101, passing score on the WPE. 1 unit.

CE 137. Water Resources Engineering. Hydrologic and hydraulic fundamentals which are common to water resources projects; introduction to reservoirs, dams, pipelines, channels, hydraulic machinery, ground water, water rights, statistical analysis, engineering economy applications, and water resources planning. Design project in urban drainage, flood control, or water supply areas. Does not satisfy ABET culminating design requirement. **Prerequisite:** ENGR 115, ENGR 132, ENGR 140. 4 units.

CE 138. Hydrology. Introduction to hydrologic engineering design. Precipitation analysis, hydrograph and flood routing applications for civil engineering. Groundwater hydrology including quality problems in development of subsurface water resources. Statistical applications in hydrology. **Prerequisite:** CE 137; may be taken concurrently. Fall only. 3 units.

CE 139. Hydraulic Flow Design. Civil Engineering design problems in open channel flow. Model design, pressure problems, design application of hydraulic analysis in structures, transitions, culverts, weirs and spillways. Channel design including roughness for subcritical and supercritical flow. Analyzes and design problems in steady, uniform, gradually and rapidly varied flow. **Prerequisite:** CE 137; may be taken concurrently. Spring only. 3 units.

CE 146. Contracts and Specifications. Business and professional relations in engineering, basic elements of contract law, construction contracts, bidding procedure, principles of specification writing. **Prerequisite:** ENGR 112. Alternate years. 3 units.

CE 147. Transportation Facility Design. Principles and methods of design of transportation facilities with emphasis on highways and on safety. Includes geometric design, facility layout, earthwork quantities, drainage facility considerations, and pavement design. Consideration of engineer's responsibility for highway safety and the engineer's role in the evolution of design standards. **Prerequisite:** CE 009 and CE 101. 3 units.

CE 148. Transportation Systems. Transportation issues and problem solving. System design methods, including data gathering and analysis, estimation of future demand, evaluation of traffic growth impacts on existing systems, and design of system components. Civil engineer's responsibility in the development and management of transportation systems. **Prerequisite:** ENGR 115, ENGR 140, CE 101, passing score on the WPE. Spring only. 3 units.

CE 161. Theory of Structures I. Analyzes statically determinate and indeterminate beams, frames, trusses and grids. Includes influence lines, moment area, conjugate beam, energy principles, slope deflection, moment distribution, flexibility method, and stiffness analysis. Computers are used to aid in the solution of complex structural problems. **Prerequisite:** CE 101, ENGR 112, MATH 032. 4 units.

CE 162. Theory of Structures II. Analyzes continuous beams and plane frames by moment distribution and direct stiffness methods. Use of symmetry in structures. Temperature, support displacement, misfit effects, and non-prismatic members. Extensive use of computer programs. Introduction to applications of matrix condensation and finite element analysis. **Prerequisite:** CE 161. Alternate years. 3 units.

CE 163. Structural Design in Steel I. Theory and practice in design of structural steel members and connections using current design specifications. Design of tension and compression members, laterally supported and unsupported beams, beam-columns, and bolted and welded connections. Use of microcomputers in design. **Prerequisite:** CE 161. 3 units.

CE 164. Reinforced Concrete Design. Theory and practice in design of reinforced concrete beams, slabs, columns, footings and retaining walls. Includes study of design, preparation and testing of cements, aggregates and concrete mixtures. **Prerequisite:** CE 161, CE 113; CE 113 may be taken concurrently. 3 units.

CE 165. Structural Design in Steel II. Continuation of CE 163. Torsion analysis and design of wide-flange beams. Analyzes and design of heavy industrial structures such as plate girders and crane girders, braced and unbraced frames. Composite floors. **Prerequisite:** CE 163. Spring only. 3 units.

CE 166. Seismic Behavior of Structures. Analyzes simple structures' response to dynamic loads with emphasis on response to earthquake ground motion. Introduction to multi-story buildings dynamics. Modal and approximate analyses of earthquake response. Dynamic analysis and building code procedures. **Prerequisite:** CE 101, CE 161, ENGR 110. Alternate years. 3 units.

CE 167. Bridge Design. Fundamental concepts of bridge design including the following aspects: aesthetics, alternative design, environmental mitigation, permits, right-of-way, agreements and route adaptions. Typical design examples of the super-structure (made of reinforced concrete/steel) are given. **Prerequisite:** CE 163, CE 164; one may be taken concurrently. Fall only. 3 units.

CE 168. Prestressed Concrete Design. Analyzes and design of prestressed concrete structures using ultimate strength and working stress methods. Detailed study of stress-strain behavior of P.C. members. Study of bond and shear. An introduction to least-weight design. **Prerequisite:** CE 161, CE 164; CE 164 may be taken concurrently. Fall only. 3 units.

CE 169A. Timber Design. Wood as a structural material. Design of sawn and glulam beams, concentrically and eccentrically loaded columns, shear walls, flexible diaphragms and connections for vertical and lateral loading including effects of wind and seismic forces. **Prerequisite:** ENGR 112. Alternate years. 3 units.

CE 169B. Reinforced Masonry Design. Reinforced masonry as a structural material. Design of reinforced masonry beams, concentrically and eccentrically loaded columns, walls for vertical and lateral loading including effects of wind and seismic forces. Design of a small building for wind and seismic loading including torsional effects. **Prerequisite:** CE 163; may be taken concurrently. Alternate years. 3 units.

CE 170. Principles of Environmental Engineering. Introduction to the principles and practices of environmental quality management. Physical and chemical principles affecting environmental quality. Water and air quality parameters, their importance, and natural processes that affect them. Introduction to treatment

processes. Solid waste management. Environmental ethics. **Prerequisite:** CE 101, ENGR 140; ENGR 140 may be taken concurrently. Passing score on the WPE. 4 units.

CE 171A. Soil Mechanics. Composition and properties of soils including compaction, permeability, consolidation, and shear strength; use of computer-based instruments for selected experiments. Lecture three hours; laboratory three hours. **Prerequisite:** CE 100, CE 101, ENGR 112. 4 units.

CE 171B. Soil Mechanics and Foundation Engineering. Lateral earth pressures and retaining walls; slope stability analysis; principles of foundation design; allowable bearing pressures; settlement of structures; shallow foundations; deep foundations. **Prerequisite:** CE 171A. Spring only. 3 units.

CE 172. Design of Environmental Engineering Hydraulic Systems. Hydraulic design of water distribution and sewerage systems. Computer-assisted pipe network analysis. Analyzes pump systems. Pump station design. Other selected topics. **Prerequisite:** CE 170, ENGR 132. Fall only. 3 units.

CE 173. Design of Water Quality Control Processes. Analyzes and design of selected physical, chemical, and biological facilities for water purification and wastewater treatment. Emphasis is on design based on loading factors and integration of unit processes into treatment systems. **Prerequisite:** CE 170, ENGR 132. Spring only. 3 units.

CE 177. Atmospheric Pollution Control. Introduction to the fundamentals of air pollution engineering. Causes, effects and control of air pollution; air pollution meteorology and air quality measurements. **Prerequisite:** ENGR 132. Alternate years. 3 units.

CE 181. Geoenvironmental Engineering. Equilibrium distribution of contaminants among air, water and solid phases of soil systems; analysis and modeling of soil vapor extraction (SVE), pump and treat, and soil washing systems; movement of gasses in landfills; infiltration through landfill cover; geosynthetic liner systems; hazardous waste containment systems. **Prerequisite:** CE 171A or instructor permission. Spring only. 3 units.

CE 184. Introduction to Earthquake Engineering. Introduction to causes of and motions associated with earthquakes; definition, measurement and prediction of earthquake parameters; response of soil deposits and structures to earthquakes; liquefaction; principles of earthquake resistant design. **Prerequisite:** CE 161, CE 171A. Fall only. 3 units.

CE 190. Senior Design Project. Completion of a group project incorporating all aspects of design from problem statement to completed design and presentation in both written and oral format. Lecture two hours; laboratory three hours. **Note:** To be taken in final semester or with consent of an academic advisor. 3 units.

CE 194. Career Development in Civil Engineering. Designed for Civil Engineering students making career decisions. Instruction will include effective career planning strategies and techniques including skill assessments, employment search strategy, goal setting, time management, interview techniques and resume writing. Lecture one hour. **Note:** Units earned cannot be used to satisfy major requirements. **Prerequisite:** Instructor permission. Cross-listed as ENGR 194, EEE194 Graded Credit/No Credit. 1 unit.

CE 195. Fieldwork in Civil Engineering. Supervised work experience in civil engineering with public agencies or firms in the industry. **Note:** May be repeated for credit. **Prerequisite:** Petition approval by supervising faculty member and Department chair. Graded Credit/No Credit. 1-3 units.

CE 195A. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. **Note:** Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. Graded Credit/No Credit. 1-12 units.

CE 195B. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. **Note:** Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. Graded Credit/No Credit. 1-12 units.

CE 195C. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. **Note:** Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. Graded Credit/No Credit. 1-12 units.

CE 195D. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. **Note:** Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. Graded Credit/No Credit. 1-12 units.

CE 196. Experimental Offerings in Civil Engineering. When a sufficient number of qualified students apply, one of the staff will conduct a pro-seminar in some topic of engineering. **Note:** May be repeated for credit with permission of adviser. 1-4 units.

CE 199. Special Problems. Individual projects or directed reading. Open only to those students who appear competent to carry on individual work. **Note:** Admission requires approval of a petition from the faculty supervising the work and the Department Chair. May be repeated for credit. Graded Credit/No Credit. 1-3 units.

Graduate Courses

In addition to those graduate courses previously listed under the general title of engineering, the following courses are of special interest to the civil engineering student.

CE 231A. Computer Methods of Structural Analysis I. Flexibility and stiffness methods of structural analysis are applied to two- and three-dimensional framed structures. The use and development of computer software to perform the analysis is discussed in detail. **Prerequisite:** CE 161 and knowledge of a scientific programming language. 3 units.

CE 231B. Computer Methods of Structural Analysis II. Continuation of CE 231A with the extension of theory to allow for the analysis of a wider variety of structures. Large general purpose computer programs utilizing computer graphics for input/output are used for the analysis of three-dimensional structures. Introduction to the fundamentals of the finite element method with applications to structural problems. **Prerequisite:** CE 231A or instructor permission. 3 units.

CE 232. Stability of Structures. Critical loads of columns and beams. Introduction to load and resistance factor design. Torsion of thin-walled members. Torsion of building structures. Stability of frames and trusses. Effect of inelastic behavior of materials. **Prerequisite:** CE 163 or CE 164 or instructor permission. 3 units.

CE 234. Dynamics and Earthquake Response of Structures. Response of structures modeled as single-degree systems to harmonic, periodic, and arbitrary excitation and earthquake ground motion; effects of damping and material nonlinearity; numerical methods using spreadsheets; response spectra. Response of structures modeled as multi-degree systems: modeling of structure mass, damping and elastic stiffness; solution by modal superposition; time-history and response spectrum analysis; implications for codes for earthquake-resistant design. Microcomputer software is extensively used. **Prerequisite:** Knowledge of the stiffness method of structural analysis. 3 units.

CE 250. Systems Analysis of Resources Development. Investigation of resource planning using the "systems approach." Objectives of resource development; basic economic and technologic concepts, and economic factors affecting system design. Consideration of evaluation, institutional constraints, and uncertainty in water resources systems. Familiarization with modern computer techniques. Applications of concepts to air and land resources. **Prerequisite:** Graduate status or instructor permission. 3 units.

CE 251. Water Resources Planning. Application of single- and multi-objective planning to the design and operation of water resources projects. Objectives and constraints for water projects, criteria and procedures for evaluation, planning under uncertainty. Application in water development and water quality planning, with case studies. **Prerequisite:** CE 250 or instructor permission. 3 units.

CE 252A. Environmental Quality Processes I. Theory and practice of chemical processes affecting water quality. Chemical equilibrium, stoichiometry and kinetics of aqueous chemistry. Acid-base, precipitation-dissolution, oxidation-reduction, and coordination chemistry. Adsorption. **Prerequisite:** CE 170 or equivalent. 3 units.

CE 252B. Environmental Quality Processes II. Theory and practice of biological processes for controlling water. Stoichiometry and kinetics of microbial growth. Aerobic and anaerobic metabolism. Engineered suspended and attached growth systems. Introduction to sludge treatment. **Prerequisite:** CE 170 or equivalent, CE 252A recommended, or instructor permission. 3 units.

CE 252C. Environmental Quality Processes III. Theory and practice of physical and chemical processes used in engineered water and wastewater systems. Adsorption, ion exchange, gas transfer, membrane processes, coagulation, flocculation, sedimentation, filtration, precipitation, disinfection, and stripping. Physical/chemical reactors. **Prerequisite:** CE 170 or equivalent, CE 252A recommended, or instructor permission. 3 units.

CE 254. Water Quality Management. Examination of pollution sources and effects on water bodies, and the management issues and tools used to protect environmental quality. Topics include point and nonpoint pollution sources, interactions in the environment, Federal and State laws, water quality objectives, beneficial uses, and regulatory mechanisms such as basin plans and total maximum daily loads (TMDLs). Emphasis is on surface water. **Prerequisite:** CE 170 or equivalent, CE 252A recommended, or instructor permission. 3 units.

CE 255. Transport of Chemicals in Soil Systems. Study of the mechanics of movement of chemicals in soil, including equilibrium and partition models, development of mass transport equations in porous media, analytical solution for one-dimensional transport, lumped parameter transport model (linear reservoir model), transport of reactive and conservative chemicals numerical solutions of transport models, transport in the unsaturated zone and coupled models for saturated and unsaturated zone. **Prerequisite:** MATH 045. Graduate status. Spring only. 3 units.

CE 261. Transportation Planning. Introduction to the complexities of comprehensive intermodal transportation planning. Study of transportation problems, system operating characteristics, alternative modes, and the planning process. Analyzes factors affecting travel behavior and methods of forecasting demand for travel by various modes. **Prerequisite:** CE 148 or instructor permission. Alternate years. 3 units.

CE 262. Advanced Transportation Facility Design. Advanced study of current topics in highway and mass transportation facility design including safety, curve design, pavement design and drainage facility design. Focuses on current design practice and recent or impending changes in design practice. **Prerequisite:** CE 147 or instructor permission. Alternate years. 3 units.

CE 263. Traffic Flow Theory. Study of traffic flow characteristics including flow rate, speed, and density, at both the microscopic and macroscopic levels. Traffic flow analysis using the theoretical methods including capacity analysis, traffic stream models, shockwave analysis, and queueing analysis. Emphasis is on theory with demonstration of practical applications. **Prerequisite:** CE 147 or CE 148; ENGR 203 or instructor permission. Alternate years. 3 units.

CE 265. Analysis and Control of Traffic Systems. Traffic data collection and analysis, practical application of theoretical methods of analysis such as capacity, level of service, and queueing theory. Investigation of traffic control techniques such as actuated signals and signal systems, and study of management techniques for traffic congestion. **Prerequisite:** CE 147 or CE 148; CE 263 or instructor permission. Alternate years. 3 units.

CE 266. Advanced Design in Reinforced Concrete. Advanced topics in behavior and design in reinforced concrete. Detailing for seismic response. **Prerequisite:** CE 161, CE 163, CE 164. 3 units.

CE 267. Structural Systems for Buildings. Analyzes and design of various structural systems for buildings: frames, tubes, shear walls with or without openings and interaction between these types. Secondary effects such as P-Δ, material and geometrical nonlinearities. **Prerequisite:** CE 232 or instructor permission. 3 units.

CE 271. Modern Hydrologic Techniques. Analyses of hydrologic and meteorologic phenomena by mathematical, statistical, and system methods, linear and non linear, stochastic and parametric hydrology, computer applications in hydrology. **Prerequisite:** CE 137 or CE 138 and ENGR 203 or instructor permission. 3 units.

CE 272. Advanced Engineering Hydraulics. Steady uniform and non-uniform open channel flows including gradually, rapid and spatially varied flows; analysis of supercritical flow in transition; basic principles of unsteady flows; long wave theory; Saint-Venant Equations and their solutions including method of characteristics, explicit and implicit finite difference numerical methods. **Prerequisite:** CE 137 or equivalent. 3 units.

CE 274. Hydrologic Modeling. Theories and structure of hydraulic model components; application of HEC-RAS (River Analysis System) and HEC-HMS (Hydrologic Modeling System) computer programs; emphasis on flood routing methods; dam safety analysis methodology including dam break and dam overtopping cases; application of microcomputers in hydraulics computations. **Prerequisite:** CE 272 or equivalent; instructor permission. 3 units.

CE 276. Groundwater Hydrology. Occurrence and movement of groundwater; physical characteristics of aquifers; analysis of steady-state groundwater flow problems by mathematical, digital computer, electrical analog and graphical methods; analysis of unsteady-state problems in confined and unconfined, aquifers; multiple well systems. **Prerequisite:** CE 137 or instructor permission. 3 units.

CE 280A. Advanced Soil Mechanics and Foundation Engineering I. Advanced analyses in soil mechanics and their practical applications in foundation engineering, including consolidation, stress distribution, settlement analyses, lateral earth pressures (including tie-back systems and earth reinforcement), bearing capacity of shallow and pile foundations, and laterally loaded piles. **Prerequisite:** CE 171A or equivalent. 3 units.

CE 280B. Advanced Soil Mechanics and Foundation Engineering II. Advanced analyses in shear strength of cohesionless and cohesive soils, slope stability analyses, and analysis and design of anchored bulkheads and cofferdams. **Prerequisite:** CE 171A or equivalent. 3 units.

CE 280C. Advanced Soil Mechanics Laboratory. Lectures and experimental studies dealing with the more advanced aspects of soil properties and their applications in design. Consolidation, strength of soils in triaxial compression testing with measurements of volume changes and pore-water pressures, dynamic soil tests, in-situ measurement techniques of soil properties such as Dutch cone, pressuremeters, and vane shear methods, advanced instrumentations, R-value and CBR tests for pavement designs and student projects. Lecture one hour; Laboratory three hours. **Prerequisite:** CE 280A. **Corequisite:** CE 280B. 2 units.

CE 283. Ground Modification Engineering. Principles of soil stabilization and earth reinforcement; mechanical compaction of difficult soils; preloading and vertical drains; dynamic deep compaction; vibro compaction and replacement; compaction grouting; jet grouting; chemical grouting; deep soil mixing; earth reinforcement; tiebacks; soil nailing. **Prerequisite:** CE 171A. 3 units.

CE 284. Soil Dynamics and Earthquake Engineering. Introduction to vibration theory; wave propagation in soils and dynamic behavior of soils and foundations; dynamic tests; analysis of dynamically loaded foundations; causes of earthquakes; earthquake magnitude and zones; ground motions induced by earthquakes; earthquake-resistant design of foundations and earth dams. **Prerequisite:** CE 171A or equivalent. 3 units.

CE 285. Geosynthetics I. Overview of geotextiles, geogrids and geonets; geosynthetic properties and test methods; geosynthetic functions and mechanisms as in separation, roadway and soil reinforcement, filtration, and drainage; applications and design methods; construction, fabrication and installation. **Prerequisite:** CE 171A or instructor permission. 3 units.

CE 286. Geosynthetics II. Overview of geomembranes, geosynthetic clay liners, and geocomposities. Topics include: geosynthetic properties and test methods; geosynthetic functions and mechanisms as in landfill liners, liquid barriers and carriers, erosion control, drainage, and design and construction methods. **Prerequisite:** CE 171A or instructor permission. 3 units.

CE 296. Experimental Offerings in Civil Engineering. When a sufficient number of qualified students is interested, one of the staff will conduct a seminar on some topic of civil engineering. **Note:** May be repeated for credit with permission of adviser. Not offered every semester. 1-4 units.

CE 299. Special Problems. Special problems in graduate research. **Note:** Approval of a petition must be obtained from the faculty supervising the work and the Department Chair. Not more than 3 units may be taken without written approval from the faculty adviser and Department Chair. Graded Credit/No Credit. 1-3 units.

CE 500. Culminating Experience. Credit given upon successful completion of either: A. Thesis (1-6 units), or B. Project (1-6 units) or C. Directed Study (1-3 units) and Comprehensive Examination. (Comprehensive Examination must be taken after completion of all course work and Directed Study.) **Prerequisite:** Advanced to candidacy and permission of the faculty advisor and Department Chair one full semester prior to registration. Graded Credit/No Credit. 1-6 units.