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 12 units (4 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 urban engineering, and water resources engineering. The BSCE degree is accredited by the Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology (EAC/ABET).

FACULTY

Ajit Virdee, *Department Chair*

Vishnu Agaskar; Joan Al-Kazily; Cyrus Aryani; Keith Bisharat; Anthony Caruso; François Cheong-Siat-Moy; Mel Holland; Leonard Hom; Ralph Hwang; Kenneth Kerri; George Kostyrko; Ramzi Mahmood; Joel Moore; William Neuman; Donald Nostrant; Donald L. Steward; Hon-Hsieh Su; Chris Tomine

Otti Cargill, *Department Secretary*
Department Office, ECS-4024, 278-6982

FEATURES

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 which is the definition and solution of engineering problems in a practical manner. Lower division, and first semester junior year coursework 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 culminating design course in the final semester.

Class sizes are small providing for close interaction between students and faculty. This interaction is enhanced in laboratory courses which are an integral part of the curriculum. 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.

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

MAJOR REQUIREMENTS • BS

Total units required for BS: 139
Total units required for Major: 60
Total units required for Pre-major: 43
Courses in parentheses are prerequisites.

Note: Courses that are prerequisites to courses taken for the major, and CE 9, ENGR 115 and 140 must be completed with a grade of "C-" or better.

A. Required Lower Division Courses (Pre-Major)

Lower division requirements are mostly common for Civil, Electrical and Electronic, and Mechanical Engineering

1. First Semester Freshman Year (17 units)

(5)	CHEM 1A*	General Chemistry
(4)	MATH 30*	Calculus I (MATH 29 or equivalent)
(2)	ENGR 4	Descriptive Geometry & CADD
(3)	General Education course	
(3)	General Education course	

2. Second Semester Freshman Year (18 units)

(4)	CE 9	Plane & Topographic Surveying (MATH 30 may be taken concurrently)
(4)	MATH 31*	Calculus II (MATH 30)
(4)	PHYS 11A	General Physics: Mechanics (MATH 30, 31; MATH 31 may be taken concurrently)
(3)	General Education course	
(3)	General Education course	

3. First Semester Sophomore Year (17 units)

(3)	ENGR 45	Engineering Materials (PHYS 11A, CHEM 1A)
(4)	MATH 32	Calculus III (MATH 31)
(4)	PHYS 11C*	General Physics: Electricity & Magnetism, Modern Physics (PHYS 11A, MATH 31)
(3)	General Education course	
(3)	General Education course	

4. Second Semester Sophomore Year (18 units)

(3)	ENGL 20	Expository Writing (ENGL 1A)
(3)	ENGR 17	Introductory Circuit Analysis (PHYS 11C, MATH 45; concurrent enrollment in MATH or PHYS but not both OK)
(3)	ENGR 30	Analytic Mechanics: Statics (PHYS 11A, MATH 31, ENGR 4)
(3)	MATH 45	Differential Equations for Science & Engineering (MATH 31)
(3)	General Education course	
(3)	General Education course	

*Indicates course which can also be used to meet University General Education requirements. Students must also satisfy the requirements of the Accreditation Board for Engineering and Technology (ABET). Consult the Civil Engineering Department Chair for specific General Education requirements.

Note 1: A second year foreign language course (2A or equivalent) may also satisfy 3 units of GE when the course is being taken to comply with the CSUS foreign language requirement. Students should consult with their advisors for exact GE eligibility of these courses.
Note 2: Courses may be interchanged between semesters to accommodate the student's schedule, as long as prerequisites are observed.

B. Required Upper Division Courses (Major)

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

1. 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 4, 30)
(3)	ENGR 110	Analytic Mechanics: Dynamics (ENGR 30, MATH 32, 45)
(3)	ENGR 112	Mechanics of Materials (ENGR 30, 45, MATH 45)
(2)	ENGR 115	Statistics for Engineers (Corequisite: MATH 31, may be taken concurrently)
(2)	ENGR 140	Engineering Economics (ENGR 17, 30, or CSC 130)
(3)	General Education course	

2. Second Semester Junior Year (18 units)

(1)	CE 113	Structural Laboratory (ENGR 112, CE 101)
(3)	CE 147°*	Transportation Facilities: Design & Operation (CE 9,100, 101) **OR** CE elective+
(4)	CE 161	Theory of Structures I (CE 101, ENGR 112, MATH 32)
(4)	CE 171A	Soil Mechanics (ENGR 112, CE 100, 101)
(3)	ENGR 132	Fluid Mechanics (ENGR 110)
(3)	General Education course	

3. First Semester Senior Year (17 units)

(3)	ENGR 124	Thermodynamics (MATH 32, PHYS 11A)
(1)	CE 135	Hydraulics Laboratory (ENGR 132, CE 101, Writing Proficiency Exam)
(3)	CE 148*	Transportation Systems: Planning & Management (ENGR 115, 140, CE 101, Writing Proficiency Exam) **OR** CE elective+
(3)	CE 163°	Structural Design in Steel I (ENGR 4, CE 161)
(4)	CE 170°	Water Quality & Supply Engineering (ENGR 132)
(3)	General Education course	

4. Second Semester Senior Year (16 units)

(4)	CE 136°	Water Resources Engineering (ENGR 132, 140; CE 170 may be taken concurrently)
(3)	CE 164°	Reinforced Concrete Design (ENGR 4, CE 161)
(3)	CE elective+	
(3)	CE elective+	
(3)	CE elective+	

+ Two CE electives are restricted to courses in design.
* Either CE 147 or 148 is required, the other may be used as an elective.
° Design courses (required curriculum provides 12 to 14 design units).

Civil Engineering Electives

Electives are to be chosen from the following courses in consultation with a faculty advisor and must include enough design electives (indicated by°) to bring total design units in the student's coursework to 16 or more. See course descriptions for prerequisites.

Fall

CE 138	Hydrology (CE 136; may be taken concurrently)
CE 166	Seismic Behavior of Structures (CE 101, 161, ENGR 110)
CE 168°	Prestressed Concrete Design (CE 161)
CE 169A°	Timber Design (ENGR 112)
CE 172°	Water Engineering Design (Corequisite CE 170)
CE 174°	Management of Hazardous Wastes (CE 170, may be taken concurrently)
CE 176°	Infrastructure Engineering (CE 171A, may be taken concurrently)
CE 177	Atmospheric Pollution Control (ENGR 132)
CE 184	Introduction to Earthquake Engineering (CE 161, 171A)

Spring

CE 139°	Hydraulic Flow Design (CE 136; may be taken concurrently)
CE 146	Contracts & Specifications (ENGR 112)
CE 162	Theory of Structures II (CE 161)
CE 165°	Structural Design in Steel II (CE 163)
CE 169B°	Reinforced Masonry Design (CE 161, 163; CE 163 may be taken concurrently)
CE 171B°	Soil Mechanics & Foundation Engineering (CE 171A)
CE 173°	Wastewater Engineering Design (ENGR 132)
CE 178	Environmental Engineering (CE 171A)
CE 181	Geoenvironmental Engineering (CE 171A)

°Indicates a design elective.

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

Cooperative Education

The Department of Civil Engineering encourages eligible students to participate in the Cooperative Education Program. Eligibility requirements are completion of the premajor 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. Most participants in this program will complete the equivalent of two six-month work periods, one in their junior year and the other in 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 two work periods. However, the credits for this course do not replace the curricular requirements of the BSCE degree. Students interested in this program should apply in the Cooperative Education Program office, EGR-1204.

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: **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 nonengineering areas (e.g., Environmental Studies, Geography, Government, and Organization Behavior and Environment) may also be arranged; **Water Resources Engineering** - advanced hydraulics and modern hydrologic techniques, flood forecasting, groundwater flow modelling, water resources management and policy formulation.

Each area of study 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 386-based work stations or McIntoshes. More sophisticated work involving CAD or computer graphics applications may be performed in the CAD/CAM laboratory of the School of Engineering and Computer Sciences. Access to mainframe computers (a cluster of VAXs) is also available, either from remote terminals strategically located on campus or by telephone line from off-campus locations. If additional computing power is needed, faculty and students have access to supercomputing.

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 Graduate Center (RFC-203).

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 grade point average of 2.8 or better, the student may apply for classified graduation 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 Student Phone Entry System (CASPER) deadlines. All prospective graduate students, including CSUS graduates, must file the following with the Graduate Center:

- an application for admission, available in the Graduate Center (RFC-215) or in the Civil Engineering Department, **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 complete a Graduate Student Advising Form (obtainable in the Civil Engineering department) and get their study program in an area of civil engineering approved by a departmental faculty advisor in that area. 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 and
- obtained classified graduate status and
- completed at least 12 units in the graduate program with a minimum 3.0 GPA, including at least three courses at the 200-level and
- passed the Writing Proficiency Examination (WPE) and
- selected and obtained approval for a culminating requirement (Plan A, B, or C).

Advancement to candidacy forms are available in the Office of Graduate Studies and Research (RFC-215). 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 and Research.

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

Degree Requirements

The Master of Science in Civil Engineering requires completion of 30 units of coursework (including research or independent study) with a minimum 3.0 GPA. An outline of degree requirement follows.

A. Required Courses by Areas of Interest (14-15 units)

(3) Select one of the following with advisor approval:

ENGR 201	Engineering Analysis I
ENGR 202	Engineering Analysis II
ENGR 203	Engineering Statistics
ENGR 204	Operations Research I

(11-12) Select four courses from one of the following Areas of Interest:

1. Environmental/Water Quality Engineering

CE 250	Systems Analysis of Resources Development
CE 252	Environmental Quality Treatment Processes
CE 253	Advanced Environmental Quality Analysis
CE 257	Industrial & Hazardous Waste Treatment
CE 258	Air Toxics
CE 276	Groundwater Hydrology

2. Geotechnical Engineering

CE 280A	Advanced Soil Mechanics & Foundation Engineering I
CE 280B	Advanced Soil Mechanics & Foundation Engineering II
CE 280C	Adv. Soil Mechanics Laboratory
CE 283	Ground Modification Engineering
CE 284	Soil Dynamics & Earthquake Engineering

3. Structural Engineering

CE 231A	Computer Methods of Structural Analysis I
CE 231B	Computer Methods of Structural Analysis II
CE 232	Stability of Structures
CE 234	Dynamics & Earthquake Response of Structures

CE 266	Advanced Design in Reinforced Concrete
CE 267	Structural Systems for Buildings

4. Transportation Engineering

CE 261	Transportation Planning
CE 262	Highway Engineering
CE 263	Traffic Flow Theory
CE 264	Mass Transportation Engineering
CE 265	Analysis & Control of Traffic Systems

5. Water Resources Engineering

CE 250	Systems Analysis of Resources Development
CE 251	Water Resources Planning
CE 271	Modern Hydrologic Techniques
CE 272	Advanced Engineering Hydraulics
CE 274	Computer Hydraulics
CE 276	Groundwater Hydrology

B. Other Course Requirements (9-13 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)

(3-6) Choose one of the following CE 500 requirements:

Plan A:	Master's Thesis (Approval by two faculty readers and a presentation are required. The thesis must comply with University standards for format and is filed in the University library.)
Plan B:	Master's Project (Approval by two faculty readers and a presentation are required. The project must comply with University standards for format and is filed in the University library.)
Plan C:	Directed Study and Comprehensive Examination (Approval of one faculty member is required for Directed Study. The comprehensve examination is administered by a committee of three faculty members).

LOWER DIVISION COURSES

9. Plane and Topographic Surveying. Instruments, methods and theories necessary for the measurement of distance, direction, angles and difference in elevation; use of data obtained in determining area and volumes; astronomical observation for the meridian. Surveys required to make large- and small—scale maps. Elementary Geodetic surveys, triangulation, adjustments, boundary surveys, and State Plan Coordinate System. Electronic equipment used in surveying. Lecture three hours, laboratory three hours per week. **Prerequisite:** MATH 30; may be taken concurrently. 4 units. (CAN ENGR 10)

UPPER DIVISION COURSES

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.

101. Computer Applications in Civil Engineering. Introduction to computer applications for solving problems in the civil engineering profession. Microcomputers and mainframe computers will be used to illustrate problem solving in various areas of civil engineering. Programming concepts used in languages such as BASIC and FORTRAN will be introduced. Specific civil engineering software packages will be utilized. General software to be applied to the solution of civil engineering problems of analysis and design, include spreadsheets, word processing scientific graphing, and statistical analysis. Illustrative problems will be taken from the areas of structural analysis and design, transportation, solid mechanics, fluid mechanics, geotechnical, sanitary engineering, and surveying. Lecture two hours, laboratory three hours. **Prerequisites:** ENGR 4, 30; and knowledge of DOS and spreadsheet usage or CSC 6B. 3 units.

113. Structural Laboratory. An 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. **Prerequisites:** ENGR 112, CE 101. 1 unit.

135. Hydraulics Laboratory. Laboratory experiments relating the principles of fluid mechanics to real fluid flow. Laboratory three hours. **Prerequisites:** ENGR 132, CE 101, Writing Proficiency Exam. 1 unit.

136. Water Resources Engineering. Application of engineering design to comprehensive water resource projects. Hydrologic and hydraulic concepts include reservoirs, dams, channels, and ground water. Designs consider engineering ethics, water law, and the economics and environmental impacts of water projects. Students work in teams to develop and present design projects based on concepts studied over their careers. **Prerequisites:** ENGR 132, 140; CE 170 may be taken concurrently. 4 units.

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 136; may be taken concurrently. Fall only. 3 units.

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. Analysis and design problems in steady, uniform, gradually and rapidly varied flow. **Prerequisite:** CE 136; may be taken concurrently. Spring only. 3 units.

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. Spring only. 3 units.

147. Transportation Facilities: Design and Operation. Introduction to the principles and methods of design of transportation facilities and traffic control devices, with emphasis on safety. Application of spread sheets and coordinate geometry software to transportation facilities design. Consideration of earthworks, drainage facility design, and traffic flow. Exploration of the engineer's professional growth and responsibility in providing safe, smooth traffic flows under prevailing fiscal and environmental constraints. Consideration of legal and ethical aspects, and the engineer's role in the evolution of design standards. **Prerequisites:** CE 9, 100, 101. 3 units.

148. Transportation Systems: Planning and Management. Introduction to data gathering, handling, and analysis for transportation engineering studies. Application of methods for estimating future demand and evaluating traffic impacts resulting from land development. Introduction to transportation issues, formulation of problems, and setting of goals, objectives and evaluation criteria. Introduction to government structure, policies, programs, funding, and financing of transportation facilities. Exploration of the engineer's professional growth and responsibility in the development and management of transportation systems. **Prerequisites:** ENGR 115, 140, CE 101, Writing Proficiency Exam. Spring only. 3 units.

161. Theory of Structures I. Analysis of 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 throughout the course to aid in the solution of complex structural problems. **Prerequisites:** CE 101, ENGR 112, MATH 32. 4 units.

162. Theory of Structures II. Analysis of 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. Spring only. 3 units.

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. **Prerequisites:** CE 161, ENGR 4. 3 units.

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. **Prerequisites:** CE 161, ENGR 4. 3 units.

165. Structural Design in Steel II. Continuation of CE 163. Torsion analysis and design of wide-flange beams. Analysis 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.

166. Seismic Behavior of Structures. Analysis of 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. **Note:** may not be used for graduate elective credit by students who take CE 234. **Prerequisites:** CE 101, 161; ENGR 110. Fall only. 3 units.

168. Prestressed Concrete Design. Analysis 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. Fall only. 3 units.

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. Fall only. 3 units.

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. Spring only. 3 units.

170. Water Quality and Supply Engineering. Design of water and wastewater facilities: transmission, storage and distribution of water; collection and removal of wastewater. Physical, chemical and biological characteristics of water and wastewater. Design of treatment processes for water and wastewater. Use of computers to design water storage and distribution systems and to forecast impacts of alternative designs on oxygen resources in receiving waters. Development and evolution of water quality standards and design practices including ethical issues. Lecture three hours, laboratory three hours. **Prerequisites:** ENGR 132, Writing Proficiency Exam. 4 units.

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. **Prerequisites:** ENGR 112, CE 100, 101. 4 units.

171B. Soil Mechanics and Foundation Engineering. Principles of foundation design; ultimate bearing capacity of soils; settlement of structures; allowable bearing pressures; methods of minimizing settlement; effect of settlement on structures; piles and pile foundations; lateral earth pressures on structures; foundation analysis. Includes use of computer programs. **Prerequisite:** CE 171A. Spring only. 3 units.

172. Water Engineering Design. Practical analysis and design of potable water treatment, conveyance and storage facilities. Emphasis on water quality, drinking water standards, water chemistry, groundwater development, well design and maintenance, surface water source development, water treatment processes (chemical coagulation, flocculation, sedimentation, and filtration); alternative filtration processes (slow sand, membrane, and package plants), disinfection (chlorine and ozone), water system planning and basic control and instrumentation systems. **Corequisite:** CE 170. Fall only. 3 units.

173. Wastewater Engineering Design. Practical design of wastewater treatment and disposal facilities. Emphasis on pretreatment facilities, secondary treatment processes (activated sludge, oxidation ditch, Sequential Batch Reactors, trickling filters, Rotating Biological Contactors, and overland flow), pond processes, disinfection, and stream and land disposal considerations. **Prerequisites:** CE 170 or 172. Spring only. 3 units.

174. Management of Hazardous Wastes. Overall management of hazardous wastes, including federal and state laws; criteria and methods for analyzing and classifying hazardous wastes; unit processes for treating hazardous wastes; resource recovery techniques; case histories of improper management of hazardous wastes and mitigating measures; siting of hazardous waste treatment and disposal facilities; California policy on land disposal facilities; alternative technology. **Prerequisite:** CE 170; may be taken concurrently. Fall only. 3 units.

176. Infrastructure Engineering. Introduction to the civil engineering aspects of infrastructure planning and development. Topics include urban planning, zoning, subdivision, and parcel maps, improvement design and regulation, traffic engineering design, utility and transportation planning including parking and transit, and urban runoff design. **Prerequisite:** Writing Proficiency Exam. **Prerequisite:** CE 171A; may be taken concurrently. Fall only. 3 units.

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. Fall only. 3 units.

178. Environmental Engineering. Prediction and evaluation of impacts of various types of human activities on the environment. Preparation and presentation of environmental impact reports. Techniques of mitigating impacts on land, water and air. Resource utilization and the recovery and recycling of waste materials, including hazardous wastes. Ethical problems in environmental engineering and their resolution. **Prerequisite:** ENGR 132 or permission of instructor. Spring only. 3 units.

181. Geoenvironmental Engineering. Soil and waste stability in design of land fills; municipal, industrial and hazardous waste control systems, clay covers and liners, geosynthetic liners, vertical barrier systems and cutoff walls; hazardous waste detection, sampling, and analysis techniques; soil remediation techniques; fate of pollutants; groundwater remediation techniques; safety issues. **Prerequisite:** CE 171A. Spring only. 3 units.

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. **Prerequisites:** CE 161, 171A. Fall only. 3 units.

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

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

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

199. Special Problems. Individual projects or directed reading. Open only to those students who appear competent to carry on individual work. Admission to this course requires approval of a petition from the faculty member under whom the individual work is to be conducted, and the department chairman. 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.

231A. Computer Methods of Structural Analysis I. The 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. **Prerequisites:** CE 161 and knowledge of a scientific programming language. Fall only. 3 units.

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. **Prerequisites:** CE 231A or permission of instructor. Spring only. 3 units.

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. Fall only. 3 units.

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. Spring only. 3 units

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 standing or permission of instructor. Fall only. 3 units.

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. Review of different levels of planning and methods applicable to each. Application in water development and water quality planning, with case studies. California Water Law and the public agency institutional environment of water planning. **Prerequisite:** CE 250 or permission of instructor. Spring only. 3 units.

252. Environmental Quality Treatment Processes. Advanced treatment of unit operations and processes employed in environmental quality control. Fundamental principles and rational design considerations of the physical, chemical, and biological unit operations and processes applicable to the design of environmental engineering systems. Topics include reactor kinetics, absorption, ion exchange, electrodialysis, and dynamics of biological processes. **Prerequisite:** CE 170 or equivalent. Fall only. 3 units.

253. Advanced Environmental Quality Analysis. Theory and application of instrumental methods of analysis as applied to the measurement for environmental control. Spectroscopy and spectrometric techniques, electromechanical analyses, chromatographic methods of analysis, light scattering and toxics measurements. **Prerequisite:** CE 170 or permission of instructor. Spring only. 3 units.

257. Industrial and Hazardous Waste Treatment. Use of liners for landfills and impoundments for the control of gases, odors and aerosols. Selection and design of physical, chemical and biological treatment processes for industrial and hazardous wastes. Consideration of waste minimization, source control, and recycling strategies. **Prerequisite:** CE 170 or permission of instructor. Spring only. 3 units.

258. Air Toxics. An examination of recent legislation addressing the problem of airborne toxics; the legal process of identification of air toxics, risk assessment, monitoring and sampling, mitigation measures, and dispersion; the impact of legislation on State agencies and local Air Quality Management District, on sources and on consulting firms. **Prerequisite:** CE 177 or permission of instructor. Spring only. 3 units.

261. Transportation Planning. Study of transportation problems and issues and introduction to the complexities of comprehensive planning for inter-modal transportation. Examination of institutional roles and responsibilities and of the planning process from problem definition through development and evaluation of alternative solutions. Analysis of factors affecting travel behavior and methods of forecasting demand for travel by the various modes. **Prerequisite:** CE 148 or permission of instructor. Not offered every semester. 3 units.

262. Highway Engineering. Advanced study of current topics in highway design, operation and maintenance, including highway safety, pavement design and management, and access for large trucks. Course focuses on current design practices and recent or impending changes in design practice. Not offered every semester. **Prerequisite:** CE 147 or permission of instructor. 3 units.

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. **Prerequisites:** CE 147 or 148, and ENGR 203 or permission of instructor. Not offered every semester. 3 units.

264. Mass Transportation Engineering. Study of the role of mass transportation in urban and rural areas; problems related to the implementation of mass transportation systems; vehicle technology, system operation, capacity, utilization and efficiency; design of rail facilities and rail & bus systems. **Prerequisite:** graduate standing in civil engineering or permission of instructor. Not offered every semester. 3 units.

265. Analysis and Control of Traffic Systems. Traffic data collection and analysis, including speed, delay, travel time and accident studies as well as practical application of theoretical methods of analysis such as capacity and level of service analysis, and queueing theory. Investigation of traffic control techniques such as actuated signals and signal systems, and study of management techniques for traffic congestion. **Prerequisites:** CE 147 or 148, and 263 or permission of instructor. Not offered every semester. 3 units.

266. Advanced Design in Reinforced Concrete. Advanced design in reinforced concrete; two-way slabs, shear walls, columns with biaxial bending, multiple column footings, pile caps, brackets and corbels; effects of torsion, shear and column slenderness. Earthquake resistant design of a small reinforced concrete building. **Prerequisites:** CE 161, 163, 164. Fall only. 3 units.

267. Structural Systems for Buildings. Analysis 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 permission of instructor. Spring only. 3 units.

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. Spring only, even years. 3 units.

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, double sweeping method; hydraulics of pipe lines including mechanics of liquid flow in pipes and pipe network systems analysis and design. **Prerequisite:** CE 136 or equivalent. Not offered every semester. 3 units.

274. Computer Hydraulics. Theories and structure of hydraulic model components; applications of HEC-2 (Water Surface Profile) and HEC-1 (Flood Hydrograph) computer programs; emphasis on flood routing methods; dam safety analysis methodology including dam break and dam overtopping cases; application of microcomputers in hydraulics computations including gradually varied flow profiles in open channels and flow in pipe network. **Prerequisite:** CE 272 or equivalent. Not offered every semester. 3 units.

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 including radial well flow in confined, unconfined, leaky and non-leaky aquifers; multiple well systems; artificial recharge; saline water intrusion. **Prerequisite:** CE 136 or permission of instructor. Fall only. 3 units.

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. Fall only. 3 units.

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. Spring only. 3 units.

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. Spring only. 2 units.

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. Spring only. 3 units.

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. Fall only. 3 units.

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. May be repeated for credit with permission of adviser. Not offered every semester; 1-4 units.

299. Special Problems. Special problems in graduate research. Approval of a petition must be obtained from the faculty member under whom the work is to be conducted, and the department chairman. Not more than 3 units may be taken without written approval from the faculty adviser and department chairman. Graded Credit/No Credit. 1-3 units.

500. Culminating Experience. Advancement to candidacy is required prior to registration. Credit given upon successful completion of either:

- **A. Thesis** (1-6), 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 coursework and Directed Study.)