CIVIL AND ENVIRONMENTAL ENGINEERING

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Chair: Richard G. Luthy
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Professors: Ronaldo I. Borja, Gregory G. Deierlein, Anne S. Kiremidjian, Peter K. Kitanidis, Jeffrey R. Koseff, Helmut Krawinkler (on leave Spring), Kincho H. Law, James O. Leckie (on leave Winter, Spring), Raymond E. Levitt, Richard G. Luthy, Stephen G. Monismith, Leonard Ortolano, Boyd C. Paulson, Jr. (on leave Autumn, Spring), Robert L. Street, Clyde B. Tatum
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Assistant Professors: Sarah L. Billington, Alexandria B. Boehm, Oliver B. Fringer, Charles A. Menun, Eduardo Miranda
Professors (Research): C. Allin Cornell, Martin Reinhard
Lecturers: Stan Christensen, William M. Critchfield, Renate Fruchter, Mark R. Kroll, John Kunz, Alexander P. Robertson, Mark Vranicar
Courtesy Professors: Peter M. Pinsky, David D. Pollard, Stephen H. Schneider, George S. Springer
Courtesy Assistant Professor: Margot G. Gerritsen
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Consulting Assistant Professors: Paolo Bazzurro, William J. Behrman, Fotini K. Chow, Olaf A. Cirpka, Murray D. Einarson, Edward S. Gross, Charles S. Han, Lisa V. Lucas, Michael L. MacWilliams, Jie Wang
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Courses in Civil and Environmental Engineering have the subject code CEE. For a complete list of subject codes, see Appendix.

The undergraduate Civil Engineering major provides a pre-professional program balancing the fundamentals common to many special fields of civil engineering with specialization in Environmental and Water Studies or Structures and Construction. The undergraduate Environmental Engineering major offers a more focused program in Environmental and Water Studies. Laboratory facilities are available to students in building energy, construction, environmental engineering and science, experimental stress analysis, fluid mechanics, structural and earthquake engineering, and advanced sensing technologies.

At least one year of graduate study is strongly recommended for professional practice. Students who contemplate advanced study at Stanford should discuss their plans with their advisers in the junior year. The coterminal B.S.-M.S. program should be considered by students who want an integrated five-year program. Potential coterminal students in Environmental Engineering and Science should be aware that applications are considered once a year, near the beginning of Winter Quarter.

For University coterminal degree program rules and University application forms, see http://registrar.stanford.edu/publications/#Coterm.

The Department of Civil and Environmental Engineering (CEE), in collaboration with other departments of the University, offers graduate degree programs in:

Construction Engineering and Management
Design/Construction Integration
Environmental and Water Studies
- Environmental Engineering and Science
- Environmental Fluid Mechanics and Hydrology

Structural Engineering and Geomechanics
- Geomechanics
- Structural Engineering

Research work and instruction under these programs are carried out in the following facilities: Building Energy Laboratory, Environmental Fluid Mechanics Laboratory (EFML), Geotechnical Engineering Laboratory, Structural Engineering Laboratory, and water quality control research and teaching laboratories. Research in earthquake engineering is conducted in the John A. Blume Earthquake Engineering Center. Research on control of hazardous substances is coordinated within the Western Region Hazardous Substance Research Center. Research and advanced global teamwork education is conducted in the Project Based Learning (PBL) Laboratory. In collaboration with the Department of Computer Science, the Center for Integrated Facility Engineering (CIFE) employs advanced CAD, artificial intelligence, communications concepts, and information management to integrate the presently fragmented participants in the facility development process and to support design and construction automation.

PROGRAMS OF STUDY

ATMOSPHERE/ENERGY

Energy and Atmosphere are linked in two primary ways. First, fossil-fuel derived energy use contributes to air pollution and climate change. Second, atmospheric winds and solar radiation are major sources of renewable energy. Because atmospheric problems can be mitigated best by increasing the efficiency with which energy is used, optimizing the use of natural energy resources, and understanding the effects of energy technologies on the atmosphere, the areas of Energy and Atmosphere are naturally coupled together.

Students in this program receive a transcript designation of Atmosphere/Energy. Courses available include those in energy resources, indoor and outdoor air pollution, energy efficient buildings, climate change, renewable energy, weather and storm systems, energy technologies in developing countries, energy systems, and air quality management, among others.

Some of the current research in the program includes projects on wind energy distribution and statistics, indoor exposure to air pollutants, the effects of a hydrogen economy on atmospheric pollution and climate, measurements of particulate matter and vehicle exhaust, hydrogen and other fuel generation by bacteria, numerical modeling of the effects of vehicles and power plants on climate, numerical weather prediction, improving the energy efficiency of buildings, improving the links between wind farms and the transmission grid, and studying the effects of aerosol particles on UV radiation and climate, among others.

Within the department, the program links to studies of water quality, environmental biotechnology, environmental fluid mechanics, sustainable construction, green buildings, and risk management. Outside the department, it links to Earth Systems, Management Science and Engineering, Mechanical Engineering, Petroleum Engineering, Urban Studies, Aeronautics and Astronautics, and Biology, among others. In addition, the program has natural connections with the Stanford Institute for the Environment (SIE), the Interdisciplinary Graduate Program in Environment and Resources (IPER), and the Global Climate and Energy Program (GCEP).

CONSTRUCTION

The Construction Engineering and Management (CEM) program prepares technically qualified students for responsible roles in all phases of the sustainable development of major constructed facilities. It emphasizes engineering and management techniques useful in planning, coordinating, and controlling the activities of diverse specialists (designers, contractors, subcontractors, and client representatives) within the unique project environment of the construction industry. By appropriate choice of elective subjects, students wishing to work for a contractor, construction management consultant, a design-build firm, or the facilities department of an owner's organization, or a construction technology firm, can design a program for their needs.

Courses offered include building systems, construction administration, construction finance and accounting, design and construction of housing, real estate development, equipment and methods, estimating, international construction, labor relations, managing human resources, planning and control techniques, productivity improvement, and project and company organizations. Additional related course work is available from other programs within the department, from other engineering departments, and from other schools in the University such as Earth Sciences and the Graduate School of Business.

The program leads to the degrees of Master of Science (M.S.), Engineer, and Ph.D. Students with undergraduate degrees in chemical, electrical, mechanical, mining, and petroleum engineering, or in architecture who do not wish to satisfy the undergraduate prerequisite courses for the M.S. in Civil and Environmental Engineering, Construction Engineering and Management, have the option of meeting the same graduate course requirements as the above and obtaining the M.S. in Engineering. Many M.S.-level graduate students and most Ph.D. candidates are supported each year through research and teaching assistantships, and through fellowships.

The Construction Program faculty and students are active participants in the Center for Integrated Facility Engineering (CIFE). In collaboration with Computer Science and other departments, CIFE conducts research on the automation, integration, and management of technology in the construction industry. The Collaboratory for Research on Global Projects (CRGP) carries out research on the special challenges of international projects in partnership with CIFE.

The program maintains close ties with the construction industry through the Stanford Construction Institute. Students participate in weekly discussions with visiting lecturers from all sectors of the U.S. construction industry.

DESIGN/CONSTRUCTION INTEGRATION

To better prepare graduates for successful careers as design and construction professionals making major contributions to integrated projects, the department offers a Master of Science (M.S.), Engineer, and Ph.D. degree field in Design/Construction Integration (DCI).

This program aims to educate design and construction professionals to understand the goals and concerns of the many other project stakeholders, and to prepare for multidisciplinary, collaborative teamwork to develop sustainable buildings and infrastructure facilities in an integrated design and construction process.

The field of Design/Construction Integration is open to applicants with backgrounds in engineering and science. Applicants should also have a background in the planning, design, or construction of facilities by virtue of previous work experience and/or their undergraduate education. Knowledge in basic subjects from the traditional areas of civil engineering is necessary for students to receive the degree and to satisfy prerequisite requirements for some of the required graduate courses.

The M.S. Degree in Design/Construction Integration requires 45 quarter units, which are normally completed in one academic year. This includes core courses in design/construction integration, structural and geotechnical engineering, and construction engineering and management, along with approved electives.

The department offers three programs related to the design and construction of facilities: Structural Engineering and Geomechanics (SEG), Construction Engineering and Management (CEM), and Design/Construction Integration (DCI).

The SEG program prepares students for careers as designers, engineering analysts, engineering risk managers, specialty consultants, or tool developers. It encompasses structural analysis and design, dynamics, earthquake engineering, risk and reliability analysis, modern computational methods, and geomechanics.

The CEM program prepares technically qualified students for responsible engineering and management roles in all phases of the development of major constructed facilities. It emphasizes management techniques useful in organizing, planning, and controlling the activities of diverse specialists working within the unique project environment of the construction industry. The program also includes the engineering aspects of heavy, industrial, and building construction.

The DCI program prepares students for multidisciplinary collaborative teamwork in an integrated design and construction process. The program extends a student's design or construction background with core courses in each of these areas and develops the background needed to understand the concerns and expertise of the many project stakeholders. It includes a comprehensive project-based learning experience.

Prospective students should use their intended career path as the primary criterion in selecting between these three programs. SEG best fits students planning to focus on designing facilities; CEM is for students planning to emphasize building facilities or managing teams and operations. Both of these degree options provide background for many different types of careers in design and construction, with some emphasis on preparation for working on projects using traditional forms of contracting and organization. Students planning careers with design or construction firms that emphasize design-build, EPC, or turnkey projects should consider DCI. All three of the degree options include substantial flexibility for students to tailor their program of study to career interests.

ENVIRONMENTAL AND WATER STUDIES

This program covers a broad spectrum of specialties, including environmental engineering and science, environmental fluid mechanics, environmental planning, and hydrology. Course offerings are scheduled to permit either intensive study in a single area or interrelated study between areas. Seminars provide a broad coverage of environmental problems. The programs are kept flexible to foster interaction among students and to encourage the development of individual programs suitable for a broad range of engineering and science backgrounds and career goals. The Stanford laboratories for water quality control and environmental fluid mechanics are well equipped and instrumented for advanced research and instruction.

Students with backgrounds in all areas of engineering and science who are interested in applying their specialized abilities to solving environmental and water problems are welcome. Comprehensive introductory courses in each major area of study are given to provide common understanding among those with dissimilar backgrounds. Courses from many other programs and departments both complement and supplement these course offerings. Some examples include Computer Science (numerical methods), Geological and Environmental Sciences (geostatistics, hydrogeology), Mechanical Engineering (applied math, experimental methods, fluid mechanics, heat transfer), Petroleum Engineering (reservoir engineering, well-test analysis), and Statistics (probability and statistics). The major areas of specialization in the two programs, environmental engineering and science, and environmental fluid mechanics and hydrology, are described below. Admissions to these two programs are handled separately; prospective students should clearly indicate their preference on their application by specifying one or the other area of specialization.

The Environmental Engineering and Science Program (EES) emphasizes the chemical and biological processes involved in water quality engineering, pollution treatment, remediation, and environmental protection. Course offerings include the biological, chemical, and engineering aspects of water supply; the movement and fate of pollutants in surface and ground waters, soil, and the atmosphere; hazardous substance control; molecular environmental biotechnology; and water and air pollution. Companion courses in the Environmental Fluid Mechanics and Hydrology Program (EFMH) include environmental planning and impact assessment, as well as environmental fluid mechanics, hydrology, and transport modeling. Research on hazardous substances is coordinated through the Western Region Hazardous Substance Research Center. The objective of this center, sponsored by the U.S. Environmental Protection Agency, is to promote through fundamental and applied research the development of alternative and advanced physical, chemical, and biological processes for the treatment of hazardous substances in the environment, with emphasis on groundwater contamination.

The Environmental Fluid Mechanics and Hydrology Program focuses on developing an understanding of the physical processes controlling the movement of mass, energy, and momentum in the water environment and the atmosphere. The program also considers environmental and institutional issues involved in planning water resources development projects. Environmental fluid mechanics courses address experimental methods; fluid transport and mixing processes; the fluid mechanics of stratified flows; natural flows in coastal waters, estuaries, lakes, and open channels; and turbulence and its modeling. Hydrology courses consider flow and transport in porous media, stochastic methods in both surface and subsurface hydrology, and watershed hydrology and modeling. Atmosphere-related courses deal with climate, weather, storms and air pollution and their modeling. Planning courses emphasize environmental policy implementation and sustainable water resources development. The research of this group is focused primarily in the Environmental Fluid Mechanics Laboratory, which includes the P. A. McCuen Environmental Computer Center.

STRUCTURAL ENGINEERING AND GEOMECHANICS

Structural engineering at Stanford encompasses computational mechanics, computer-aided engineering, risk and reliability analysis, structural analysis and design, and teaching and research programs in earthquake engineering and structural dynamics. The programs are designed to provide a broad knowledge in these fields and to prepare students for industrial or academic careers. Academic programs can be designed to meet the needs of students wishing to launch careers as consultants on large and small projects, designers, and engineering analysts. Students have the opportunity to balance strong engineering fundamentals with modern computational methods.

Course work in earthquake engineering and structural dynamics provides an understanding of the earthquake phenomenon, the resulting ground shaking, and in-depth knowledge on the behavior, analysis, and design of various types of structures under seismic or other dynamic forces. Automated structural monitoring devices and control systems, and the utilization of advanced materials for civil infrastructures and seismic retrofits, are part of the ongoing research activities. Advanced analytical and experimental research in earthquake engineering is conducted at the John A. Blume Earthquake Engineering Center, which houses static and dynamic testing equipment including two shaking tables.

Reliability and risk analysis focuses on instruction and research in advanced methods for structural safety evaluation and design, including methods for loss estimation from damage and failures of structures and lifeline systems. Course work combines a strong background in structural analysis and design with probability theory and statistics. Research deals with regional loss and damage evaluation, reliability of marine systems, seismic risk and reliability of large structural systems, and wind hazards.

Courses and research in structural analysis and design focus on the conceptual and detailed design of structural systems and on computational methods for predicting the static and dynamic, linear and non-linear response of structures. Included are courses that emphasize earthquake resistant design, design with high-performance materials, and computer-based design concepts. Related course work is available from other departments such as Computer Science, Materials Science and Engineering, and Mechanical Engineering. In collaboration with CIFE, issues involving design for constructibility, engineering information management and collaborative engineering are addressed as an integral part of the research.

Computational mechanics emphasizes the application of modern computing methods to structural engineering and geomechanics. It draws on the disciplines of computer science, mathematics, and mechanics, and encompasses numerical structural and geotechnical analysis, including finite element analysis and boundary element methods. There is collaborative research in high performance computing with the Scientific Computing and Computational Mathematics Program.

Students with primary interests in the application of the principles of applied mechanics to problems involving geologic materials have the option of enrolling in a degree program in geomechanics. This program focuses on instruction and research in theoretical soil and rock mechanics, computational methods, and analysis and design of foundations and earth structures. In addition to the program's offerings, related courses are available in construction engineering, earth sciences, structural engineering, and the water resources program.

UNDERGRADUATE PROGRAMS

BACHELOR OF SCIENCE

The B.S. in Civil Engineering is an ABET accredited program as is the newly initiated B.S. in Environmental Engineering. High priority is placed on integrating research with engineering education. Four major objectives structure both degree programs:

1. To provide an understanding of engineering principles and the analytical, problem solving, design, and communication skills to continue succeeding and learning in diverse careers.
2. To prepare for successful engineering practice with a longer term perspective that takes into account new tools such as advanced information technology and biotechnology, and increasingly complex professional and societal expectations.
3. To prepare for possible graduate study in engineering or other professional fields.
4. To develop the awareness, background, and skills necessary to become responsible citizens and leaders in service to society.

Students who major in Civil Engineering or in Environmental Engineering must complete the appropriate requirements for the B.S. degree listed under Undergraduate Programs in the "School of Engineering" section of this bulletin. Elective units may be used in any way the student desires, including additional studies in civil and environmental engineering. Because the undergraduate engineering curriculum is designed to ensure breadth of study, students who intend to enter professional practice in civil or environmental engineering should plan to obtain their professional education at the graduate level.

A number of undergraduate programs at Stanford may be of interest to students seeking to specialize in environmental studies. In addition to the two majors offered within our own department, interested students should examine related programs such as Earth Systems, Geological and Environmental Sciences, Urban Studies, and Human Biology.

HONORS PROGRAM

This program leads to a B.S. with Honors in Civil Engineering or in Environmental Engineering. It is designed to encourage highly qualified students in an engineering major to undertake a more intensive study of civil and environmental engineering than is required for the normal major via a substantial, independent research project.

The program involves an in-depth research study in an area proposed to and agreed to by a Department of Civil and Environmental Engineering (CEE) faculty adviser and completion of a thesis of high quality. A written proposal for the research to be undertaken must be submitted and approved in the fourth quarter prior to graduation. At the time of application, the student must have an overall grade point average (GPA) of at least 3.3 for course work at Stanford; this GPA must be maintained to graduation. The thesis is supervised by a CEE faculty adviser and must involve input from the School of Engineering Writing Program by means of ENGR 102S or its equivalent. The written thesis must be approved by the thesis adviser. Students are encouraged to present their results in a seminar for faculty and other students. Up to 10 units of CEE 199H, Undergraduate Honors Research in Civil and Environmental Engineering, may be taken to support the research and writing (not to duplicate ENGR 102S). These units are beyond the normal Civil Engineering or Environmental Engineering program requirements.

MINOR IN CIVIL ENGINEERING OR ENVIRONMENTAL ENGINEERING

The department offers B.S. minor programs in both Civil Engineering and Environmental Engineering. Departmental expertise and undergraduate course offerings are available in the areas of Architectural Engineering, Construction Engineering, Construction Management, Structural/Geotechnical Engineering, Environmental Engineering and Science, Environmental Fluid Mechanics and Hydrology, and in Energy. The courses required for the minors typically have prerequisites; students need to check what these are for their choice of minor. The minimum prerequisite for a Civil Engineering minor is MATH 42 (or MATH 21); however, many courses of interest require PHYSICS 53 and/or MATH 51 as prerequisites. Students should recognize that minors are not ABET-accredited programs.

Since undergraduates having widely varying backgrounds may be interested in obtaining a minor, no single set of course requirements is appropriate for all students. Instead, interested students are encouraged to propose their own set of courses within prescribed guidelines and submit it for review and approval by the undergraduate minors adviser for the department, Professor Robert Street. Guidelines on a minor for either Civil Engineering or Environmental Engineering and example programs are available in the department's office of student services in Terman Engineering, Room M42, or at http://cee.stanford.edu.

GRADUATE PROGRAMS

The University requirements governing the M.S., Engineer, and Ph.D. are described in the "Graduate Degrees" section of this bulletin.

Admission—Applications require online submission of the application form and statement of purpose, followed by three letters of recommendation, results of the General Section of the Graduate Record Examination, and transcripts of courses taken at colleges and universities. Go to http://gradadmissions.stanford.edu/. Policies for each of the department's programs are available by referring to http://cee.stanford.edu.

Successful applicants are advised as to the degree and program for which they are admitted. If students wish to shift from one CEE program to another after being accepted, an application for the intradepartmental change must be filed within the department; they will then be advised whether the change is possible. If, after enrollment at Stanford, students wish to continue toward a degree beyond the one for which they were originally admitted, a written application must be made to the Department of Civil and Environmental Engineering.

Financial Assistance—The department maintains a continuing program of financial aid for graduate students. Applications for financial aid and assistantships should be filed by December 14, 2004; it is important that Graduate Record Examination scores be available at that time. Applicants not requesting financial assistance have until March 29, 2005 for the online submission.

Teaching assistantships carry a salary for as much as one-half time work to assist with course offerings during the academic year. Up to half-time research assistantships also are available. Engineer and Ph.D. candidates may be able to use research results as a basis for the thesis or dissertation. Assistantships and other basic support may be supplemented by fellowship and scholarship awards or loans. Continued support is generally provided for further study toward the Engineer or Ph.D. degree based on the student's performance, the availability of research funds, and requisite staffing of current projects.

MASTER OF SCIENCE

The following programs are available leading to the M.S. degree in Civil and Environmental Engineering: Atmosphere/Energy, Construction Engineering and Management, Design/Construction Integration, Environmental Engineering and Science, Environmental Fluid Mechanics and Hydrology, Geomechanics, and Structural Engineering.

Students admitted to graduate study with a B.S. in Civil Engineering (or its equivalent) from an accredited curriculum can satisfy the requirements for the M.S. degree in Civil and Environmental Engineering by completing a minimum of 45 units of study beyond the B.S. All 45 units must be taken at Stanford. A minimum 2.75 grade point average (GPA) is required for candidates to be recommended for the M.S. degree. No thesis is required.

The program of study must be approved by the faculty of the department and should include at least 45 units of courses in engineering, mathematics, science, and related fields unless it can be shown that other work is pertinent to the student's objectives.

Candidates for the M.S. in Civil and Environmental Engineering who do not have a B.S. in Civil Engineering may, in addition to the above, be required to complete those undergraduate courses deemed important to their graduate programs. In such cases, more than three quarters is often required to obtain the degree. Students may, with the approval of their academic adviser, select a program that satisfies the requirements for the M.S. in Engineering.

Forms required for the degree may be secured from the department's office of student services.

ENGINEER

A student with an M.S. in Civil Engineering may satisfy the requirements of the degree of Engineer in Civil and Environmental Engineering by completing 45 unduplicated course work and research units for the degree and minimum residency of 90 total units. Engineer candidates must submit an acceptable thesis (12 to 15 units) and maintain a minimum GPA of 3.0. The program of study must be approved by a faculty member in the department.

This degree is recommended for those desiring additional graduate education, especially those planning a career in professional practice. The thesis normally should be started in the first quarter of graduate study after the M.S. degree. Programs are offered in the fields of specialization mentioned for the M.S. degree. The Engineer thesis topic, for students who will continue study toward a CEE Ph.D., must be significantly different from their doctoral research.

DOCTOR OF PHILOSOPHY

The Ph.D. is offered under the general regulations of the University as set forth in the "Graduate Degrees" section of this bulletin. This degree is recommended for those who expect to engage in a professional career in research, teaching, or technical work of an advanced nature. The Ph.D. program is rigorous and should be undertaken only by students with ability for independent work. It requires a total of 135 units of graduate study, at least two years of which must be at Stanford with a minimum GPA of 3.0 in post-M.S. course work. Experience has shown that few students complete the Ph.D. within the minimum residence period. Prospective doctoral students should anticipate the possibility of at least one extra year. All candidates for the Ph.D. degree are required to complete CEE 200 in conjunction with a one-quarter teaching assistantship/course assistantship to gain training and instructional experience. Further information on Ph.D. requirements and regulations is found in the department handbook.

The first year of graduate study can be represented by the M.S. program described above. The second year is devoted partly to additional graduate courses and partly to preliminary work toward a dissertation. The third and subsequent years are applied to further course work and to the completion of an acceptable dissertation.

The program of study is arranged by the prospective candidate at the beginning of the second year with the advice of a faculty committee whose members are nearest in the field of interest to that of the student. The chair of the committee serves as the student's pro tem adviser until such time as a member of the faculty has agreed to direct the dissertation research. Insofar as possible, the program of study is adapted to the interests and needs of the student within the framework of the requirements of the department and the University.

In the second year of graduate study, the student is expected to pass the department's General Qualifying Examination (GQE) to be admitted to candidacy for the doctoral degree. The purpose of the GQE is to ensure that a student is adequately prepared to undertake doctoral research and has a well planned research topic. The exam may take the form of (1) a written and/or oral general examination of the candidate's major field, (2) a presentation and defense of the candidate's doctoral research dissertation proposal, or (3) a combination research proposal and general examination. The GQE is administered by an advisory committee consisting of at least three Stanford faculty members, including a chair who is a faculty member in Civil and Environmental Engineering. All members are normally on the Stanford Academic Council. A petition for appointment of one advisory committee member who is not on the Academic Council may be made if the proposed person contributes an area of expertise that is not readily available from the faculty. Such petitions are subject to approval by the department chair.

PH.D. MINOR

A Ph.D. minor is a program outside a major department. Requirements for a minor are established by the minor department. Acceptance of the minor as part of the total Ph.D. program is determined by the major department. Application for Ph.D. minor must be approved by both the major and the minor department, and the minor department may be represented at the University oral examination.

A student desiring a Ph.D. minor in Civil and Environmental Engineering (CEE) must have a minor program adviser who is a regular CEE faculty member in the program of the designated subfield. This adviser must be a member of the student's University oral examination committee and the reading committee for the doctoral dissertation.

The program must include at least 20 units of graduate-level course work (that is, courses numbered 200 or above, excluding special studies and thesis) in CEE completed at Stanford University. The list of courses must form a coherent program and must be approved by the minor program adviser and the CEE chair. A minimum GPA of at least 3.0 must be achieved in these courses.

HONORS COOPERATIVE PROGRAM

Some of the department's graduate students participate in the Honors Cooperative Program (HCP), which makes it possible for academically qualified engineers and scientists in industry to be part-time graduate students in Civil and Environmental Engineering while continuing professional employment. Prospective HCP students follow the same admissions process and must meet the same admissions requirements as full-time graduate students. For more information regarding the Honors Cooperative Program, see the "School of Engineering" section of this bulletin.

COURSES

WIM indicates that the course satisfies the Writing in the Major requirements. (AU) indicates that the course is subject to the University Activity Unit limitations for undergraduates (8 units maximum).

UNDERGRADUATE

CEE 31. Accessing Architecture Through Drawing—Same content as 31Q except offered as a regular course. Limited enrollment.
4 units, Win (Barton)

CEE 31Q. Accessing Architecture Through Drawing—Stanford Introductory Seminar. Preference to sophomores. Drawing architecture provides a deeper understanding of the intricacies and subtleties that characterize contemporary buildings. How to dissect buildings and appreciate the formal elements of a building, including scale, shape, proportion, colors and materials, and the problem solving reflected in the design. Students construct conventional architectural drawings, such as plans, elevations, and perspectives. Limited enrollment.
4 units, Aut (Walters)

CEE 46Q. Fail Your Way to Success—Stanford Introductory Seminar. Preference to sophomores. How to turn failures into successes; cases include minor personal failures and devastating engineering disasters. How personalities and willingness to take risks influence the way students approach problems. Field trips, case studies, and guest speakers applied to students' day-to-day interactions and future careers. Goal is to redefine what it means to fail. GER:2b
3 units, Spr (Clough)

CEE 63. Weather and Storms—(Graduate students register for 263C.) Survey of daily and severe weather, and global climate. Topics: structure and composition of the atmosphere, fog and cloud formation, rainfall, local winds, global circulation, jet streams, high and low pressure systems, inversions, el Niño, la Niña, atmosphere-ocean interactions, fronts, cyclones, thunderstorms, lightning, tornadoes, hurricanes, pollutant transport, global climate, and atmospheric optics. GER:2a
3 units, Aut (M. Jacobson)

CEE 64. Air Pollution: From Urban Smog to Global Change—(Graduate students register for 263D.) Survey of urban through global-scale air pollution. Topics: the evolution of the earth's atmosphere, indoor air pollution, urban smog formation, effects of exposure to air pollution, visibility, acid rain, global climate change, stratospheric ozone reduction, Antarctic ozone destruction, air pollution transport across political boundaries, the effects of meteorology on air pollution, and the effects of air pollution and stratospheric ozone on human exposure to ultraviolet radiation. GER:2a
3 units, Spr (M. Jacobson)

CEE 66. Energy Production and its Impact on the Atmosphere—Physical and technical issues associated with current and future energy use. The physics of energy including solar, chemical, thermal, and nuclear. How to calculate or estimate the energy content of systems. What are likely sources of future energy needs? Projected changes during the 21st century, basic scientific information needed to make informed choices, and potential renewable energy resources.
3 units, Aut (Tabazadeh)

CEE 70. Environmental Science and Technology—Introduction to environmental quality and technical background for understanding environmental issues, controlling environmental degrading, and preserving air and water quality. Material balance concepts for tracking substances in the environmental and engineering systems. Environmental laws relating to water and air quality, and control of hazardous materials; the technical basis for policy and environmental risk. Three-day field project to quantify the flux of pollutants from a local watershed outlet to the ocean or bay. GER:2b
3 units, Aut (Boehm)

CEE 80N. The Art of Structural Engineering—Stanford Introductory Seminar. Preference to freshmen. The history of modern bridges, buildings, and other large-scale structures. Principles of structural engineering through case studies. Analysis of structural form with scientific, social, and symbolic considerations. Field trip to Bay Area landmark and hands-on exercises including building and testing a model bridge. Goal is appreciation of modern structures, their social context, and the art of structural engineering. Students from all backgrounds welcome. GER:2b
4 units, Aut (Billington)

CEE 99A,B,C. Environmental Issues Seminar
1 unit, **A:** *(Staff) not given 2004-05,* **B:** *Win (Kitanidis),*
C: *(Staff) not given 2004-05*

CEE 100. Managing Sustainable Building Projects—The facility life cycle and project delivery organization emphasizing life cycle concerns including cost, first cost, project schedule and organization, and sustainability. Techniques for organizing, and executing civil engineering projects from conception to completion. Project objectives such as scope, quality, cost, time, and safety from multiple perspectives. Roles, responsibilities, and risks for project participants including owners, designer, and builders. Time and cost planning and control including scheduling and cost estimating techniques using information technology. Virtual design and construction technologies. Small team, real world projects; individual paper. Recommended: CEE 111. GER:2b,WIM
3-4 units, Aut (Fischer)

CEE 101A. Mechanics of Materials—Introduction to beam and column theory. Normal stress and strain in beams under various loading conditions; shear stress and shear flow; deflections of determinate and indeterminate beams; analysis of column buckling; structural loads in design; strength and serviceability criteria. Lab experiments. Prerequisites: ENGR 14. GER:2b

4 units, Win (Staff)

CEE 101B. Mechanics of Fluids—Physical properties of fluids and their effect on flow behavior; equations of motion for incompressible ideal flow, including the special case of hydrostatics; continuity, energy, and momentum principles; control volume analysis; laminar and turbulent flows; internal and external flows in specific engineering applications including pipes, open channels, estuaries, and wind turbines. Prerequisites: PHYSICS 53, MATH 51. GER:2b

4 units, Spr (Koseff)

CEE 101C. Geotechnical Engineering—Introduction to the principles of soil mechanics. Soil classification, shear strength and stress-strain behavior of soils, consolidation theory, analysis and design of earth retaining structures, introduction to shallow and deep foundation design, slope stability. Lab projects. Prerequisite: ENGR 14. Recommended: 101A. GER:2b

3-4 units, Aut (Borja)

CEE 101D. Mathematical Laboratory Applications in Civil and Environmental Engineering—(Graduate students register for 201D.) Use of commercial professional software in the design and analysis of civil and environmental engineering systems. MATLAB 5 is applied to relevant problems and issues that students encounter in subsequent courses and in engineering practice. Limited enrollment.

2 units, Aut (Kitanidis)

CEE 102. Legal Aspects of Engineering and Construction—Introduction to the U.S. legal system as it applies to civil engineering and construction. Fundamental concepts of contract and tort law, claims, risk management, business formation and licensing, agency, insurance and bonding, and real property.

3 units, Win (London)

CEE 111. 3D Modeling Plus Analyses—Modeling, visualization, and graphical communication of civil engineering projects, 3D CAD and use of 3D models for analysis including 4D modeling and sustainability concerns such as energy simulation and lighting analysis. Underlying computer representations, applications of 3D models and related analyses in design, construction, and building operations. Lab exercises, class project. Coordinated with CEE100. Prerequisite: 100 or consent of instructor. GER:2b

3 units, Aut (Fischer)

CEE 115A,B,C,D. Industry Seminar and Internship Program—(Graduate student register for 215.) Each Wednesday, a civil engineering industry representative facilitates a noon brown bag class on a topic relevant to an industry segment. 10-20 speakers per year. During the year, students and companies match interests and make employment arrangements for the following summer. Students write brief reports to faculty and industry advisers for class credit.

1 unit, **A:** *Aut (Clough),* **B:** *Win (Fischer),* **C:** *Spr (Clough),* **D:** *Sum (Staff)*

CEE 122A,B. Computer Integrated Architecture/Engineering/Construction (A/E/C)—(Undergraduates serve as apprentices in 222A,B; see 222A,B.)

2 units, **A:** *Win (Fruchter),* **B:** *Spr (Fruchter)*

CEE 130. Introduction to Architecture Studio—Principles of and approaches to architectural design. Architectural models as a primary design tool. Incrementally staged design projects explore conventional design guidelines and creative design strategies. Final project applies aesthetic principles and individual strategies to the design of a simple building. Limited enrollment.

4 units, Win (Walters)

CEE 131. Architectural Design Process—Fundamental issues in the architectural profession including design theory, professional practice concerns, site analysis. and design process. Building/landscape design case study project in model form and using architectural graphics exercises.

4 units, Spr (Blake, Todd)

CEE 132. Interplay of Architecture and Engineering—Requirements that drive a building's design including architecture, engineering, constructability, building codes, and budget. Case studies illustrate how structural and mechanical systems are integrated into building types including residential, office, commercial, and retail. In-class studio work.

4 units, Win (Katz)

CEE 134. The Architecture of the House—Studio course on the design of the single family home. Emphasis is on identification and review of the typical house form and its elements. Architectural form in the context of local planning regulations, space making fundamentals, structure, concept, and sustainability. Students work in drawings, model, and computer as appropriate.

4 units, Aut (Barton)

CEE 135. Building Modeling Workshop—(Formerly URBANST 168.) Computer-aided drafting, modeling, and rendering techniques. The capabilities and applications of leading architectural design tools such as AutoCAD, Revit, Viz, and Photoshop in four intensive training sessions. Supervised work on computers. Assignments apply these tools to build CAD models of familiar building projects. Five course meetings; limited enrollment.

2 units, Aut (Katz)

CEE 136. Green Architecture—Goal is to develop a working definition of ecologically sustainable design and strategies for greening the built environment. Readings, discussion, and research lay the groundwork for an architectural design studio which explores the student and faculty inspired green dorm initiative. Limited enrollment. Preference to students with design or environmental engineering experience. GER:2b

4 units, Aut (B. Jacobson)

CEE 137. Architectural Design of Individual Buildings: Ethics, Community Service, and Social Responsibility—Community service oriented studio course emulates a design office and requires students to prepare concept-level designs for real projects. Projects may involve small on-campus facilities such as a campus bicycle repair facility, or off-campus facilities for economically disadvantaged communities in developing countries such as an orphanage or teen center in a Mexican town. Prerequisite: at least one other Architecture Studio course, or consent of instructor. Limited enrollment.

3-6 units, Spr (Jann)

CEE 139. Design Communication Methods—Preference to students in CEE, Urban Studies, and Art. Students present designs completed in other studio courses to communicate design intentions and other aspects of their work. Instruction in photography. Preparation of a design portfolio. Oral presentation workshops offered through the Center for Teaching and Learning. Limited enrollment. Prerequisites: two Art or Architecture Studio courses, or consent of instructor.

3 units, Spr (Barton, Walters)

CEE 140. Field Surveying Laboratory—Friday afternoon laboratory provides practical surveying experience. Some additional morning classes to prepare for afternoon sessions. Operation of common field survey tools; introduction to the newest generation of digital measuring, positioning, and mapping tools. Emphasis is on using field data as the basis for subsequent engineering and economic decisions. GER:2b

3 units, Spr (Williams)

CEE 141. Project for ASCE: Design and Construction of Steel Bridge—Design, construction, and testing of steel bridge; selection of materials and construction methods; participation in regional competition.

1 unit, Aut, Win, Spr (Staff)

CEE 143. Virtual Design and Construction—(Graduate students register for 243.) Computer-based models in building design and construction. Virtual design and construction (VDC) is the use of multidisciplinary performance models of design-construction projects, including the product (facilities), work processes, organization of the design-construction-operation team, and economic impact (model of both cost and value of capital investments) in order to support business objectives. Successful participation may allow students a 4-day mini-internship at an A/E/C company over Spring break. Recommended: 241, 242.
3-4 units, Win (Kunz)

CEE 147. Cases in Personality, Leadership, and Negotiation—(Graduate students register for 247.) Case studies target leadership, risk willingness, and life skills essential for real world success. Personality and thinking styles of the student and difficult people. Failures, successes, and risk willingness examined in individual and group tasks based on the professor's thirty years of experience as a small business owner and construction engineer. Required full afternoon field trips to local sites. Limited to matriculating students; mandatory first class attendance.
4 units, Spr (Clough)

CEE 148. Design and Construction of Affordable Housing—Planning, design, engineering, and construction in the development of affordable housing. Topics: the socioeconomic context of affordable housing; stages in property development; issues in design; types of structures, methods, and materials used in housing construction; and property management. Students apply what they learn in assignments where they interact with non-profit housing developers, city planning officials, and architects. Two Saturday field trips to affordable housing developments. GER:2b
3-4 units, Win (Paulson)

CEE 151. Negotiation—(Graduate students register for 251; same as MS&E 285, ME 207.) Introduction to negotiation styles and processes in order to help students conduct and review negotiations. Workshop format integrating intellectual and experiential learning. Students analyze the negotiation process through exercises, live and field examples, individual and small group reviews. Students must apply before the first day of class. See course website for details. Enrollment limited to 50.
3 units, Aut, Spr (Christensen)

CEE 154. Cases in Estimating Costs—(Graduate students register for 254.) Case studies of business decisions based on rational cost estimating in competitive markets. Emphasis is on the fundamental forces driving the construction industry as seen on site visits; general principles applicable to any competitive business. Cases based on the professor's thirty years of experience as a small business owner and construction engineer. Full afternoon field trips to local sites. Prerequisite: matriculating student; mandatory first class attendance. GER:2b
3 units, Aut (Clough)

CEE 156. Building Systems—(Graduate students register for 256.) Design concepts, options for increased sustainability, integration issues, construction materials, and installation operations for heating, ventilating, and air conditioning systems. Overview of other building systems. Corequisite for undergraduates: 156A. GER:2b
3 units, Win (Staff)

CEE 156A. Building System Design Experience—Design of the heating, ventilating, and air conditioning system for a commercial building project shared with 181A/B. Types of design constraints. Corequisite: 156.
1 unit, Win (Staff)

CEE 160. Mechanics of Fluids Laboratory—Lab experiments and demonstrations illustrate conservation principles and flows of real fluids. Corequisite: 101B.
2 units, Spr (Monismith)

CEE 161A. Rivers, Streams, and Canals—(Graduate students register for 264A.) Introduction to the movement of water through natural and engineered channels, streams, and rivers. Basic equations and theory (mass, momentum, and energy equations) for steady and unsteady descriptions of the flow. Application of theory to the design of flood-control and canal systems. Flow controls such as weirs and sluice gates; gradually varied flow; Saint-Venant equations and flood waves; and method of characteristics. Open channel flow laboratory experiments: controls such as weirs and gates, gradually varied flow, and waves. Students taking lab section register for 4 units. Prerequisites: 101B, 160. GER:2b
3-4 units, Aut (Street)

CEE 162. Modeling and Simulation for Civil and Environmental Engineers—Introduction to mathematical and computational methods for modeling and simulation and the use of the Simulink toolbox in Matlab to cover topics including transport, air and water quality, reservoir, and global climate modeling. Course is application driven; students work in groups on three projects with an extensive final project. Prerequisites: CME 100, 102 (formerly ENGR 154, 155A) or equivalent. GER:2a
3 units, Spr (Fringer)

CEE 164. Introduction to Physical Oceanography—(Graduate students register for 262D; same as EARTHSYS 164.) Introduction to the dynamic basis of physical oceanography. Topics: a general description of the physical environment of the ocean; conservation equations for salt, heat, and momentum; geostrophic flows; wind-driven flows; the Gulf Stream; equatorial dynamics and ENSO; the thermohaline circulation of the deep oceans; and tides. Prerequisite: PHYSICS 53. GER:2a
4 units, Win (Fong)

CEE 166A. Watersheds and Wetlands—(Graduate students register for 266A.) An introduction to the occurrence and movement of water in the natural environment and its role in creating and maintaining terrestrial, wetland, and aquatic habitat. Hydrologic processes, including precipitation, evaporation, transpiration, snowmelt, infiltration, subsurface flow, runoff, and streamflow. Rivers and lakes, springs and swamps. Emphasis is on observation and measurement, data analysis, modeling, and prediction. Prerequisite: 101B or equivalent. GER:2b
3 units, Aut (Freyberg)

CEE 166B. Floods and Droughts, Dams and Aqueducts—(Graduate students register for 266B.) Sociotechnical systems associated with human use of water as a resource and the hazards posed by too much or too little water. Potable and non-potable water use and conservation. Irrigation, hydroelectric power generation, rural and urban water supply systems, storm water management, flood damage mitigation, and water law and institutions. Emphasis is on engineering design. Prerequisite: 166A or equivalent. GER:2b
3 units, Win (Freyberg)

CEE 166D. Water Resources and Water Hazards Field Trips—(Graduate students register for 266D.) Introduction to water use and water hazards via weekly field trips to local and regional water resources facilities (dams, reservoirs, fish ladders and hatcheries, pumping plants, aqueducts, hydropower plants, and irrigation systems) and flood damage mitigation facilities (storm water detention ponds, channel modifications, flood control dams, and reservoirs). Each trip preceded by an orientation lecture.
2 units, Win (Freyberg)

CEE 169. Environmental and Water Resources Engineering Design—Application of fluid mechanics, hydrology, water resources, environmental sciences, and engineering economy fundamentals to the design of a system addressing a complex problem of water in the natural and constructed environment. Problem changes each year, generally drawn from a challenge confronting the University or a local community. Student teams prepare proposals, progress reports, oral presentations, and a final design report. Prerequisite: senior in Civil Engineering or Environmental Engineering; 166B.
5 units (Freyberg) alternate years, given 2005-06

CEE 171. Environmental Planning Methods—For juniors and seniors. Use of microeconomics and mathematical optimization theory in the design of environmental regulatory programs; tradeoffs between equity and efficiency in designing regulations; techniques for predicting visual, noise, and traffic impacts in environmental impact assessments. Prerequisites: 70, MATH 51. GER:2b
3 units, Win (Ortolano)

CEE 172. Air Quality Management—Quantitative introduction to the engineering methods used to study and seek solutions to current air quality problems. Topics: global atmospheric changes, urban sources of air pollution, indoor air quality problems, design and efficiencies of pollution control devices, and engineering strategies for managing air quality. Prerequisites: 70, MATH 51. GER:2b
3 units, Win (Hildemann)

CEE 173A. Energy Resources—(Graduate students register for 207A; same as EARTHSYS 103.) Overview of oil, natural gas, coal, nuclear, hydro, solar, geothermal, biomass, wind, and ocean energy resources in terms of supply, distribution, recovery and conversion, environmental impacts, economics, policy, and technology. The opportunities for energy efficiency, electric power basics, the changing role of electric utilities, transportation basics, and energy use in developing countries. Field trips. Recommended: 70. GER:2b
4-5 units, Aut (Woodward)

CEE 173B. The Coming Energy Revolution—(Graduate students register for 207B.) The forces driving an energy revolution: environmental pressures; global, social, and economic revolution; and technological change. Assessment of evolution versus revolution, developed versus developing countries, transportation, electric power, resource development and extraction, end use technologies, deregulation, privatization and globalization, barriers to change, and the mechanisms to overcome them. Enrollment limited to 15. Prerequisite: 173A. GER:2b
4 units (Woodward) not given 2004-05

CEE 173G. Technology Implementation for Sustainable Development in Developing Countries—(Graduate students register for 207G.) Case studies: societal, institutional, and technological contexts; scientific, engineering, and economic aspects; technical suitability; implementation; and potential societal impact.
3 units, Win (Gadgil)

CEE 175. Environmental Economics and Policy—(Enroll in ECON 155, EARTHSYS 112.)
5 units, Spr (Goulder)

CEE 176A. Energy Efficient Buildings—Analysis and design. Thermal analysis of building envelope, heating and cooling requirements, daylighting, and HVAC systems. Emphasis is on residential passive solar design, and solar water heating. Lab. Prerequisite: 173A. GER:2b
3-4 units, Win (Masters) alternate years, not given 2005-06

CEE 176B. Electric Power: Renewables and Efficiency—Renewable and efficient electric power systems emphasizing analysis and sizing of photovoltaic arrays and wind turbines. Basic electric power generation, transmission and distribution, distributed generation, combined heat and power, fuel cells. End use demand, including lighting and motors. Lab. Prerequisite: 173A. GER:2b
3-4 units (Masters) alternate years, given 2005-06

CEE 176F. Energy Systems Field Trips
1-2 units, Win (Masters)

CEE 177. Aquatic Chemistry and Biology—Undergraduate-level introduction to the chemical and biological processes in the aqueous environment. Basic aqueous equilibria; the structure, behavior, and fate of major classes of chemicals that dissolve in water; redox reactions; the biochemistry of aquatic microbial life; and biogeochemical processes that govern the fate of nutrients and metals in the environment and in engineered systems. Prerequisite: CHEM 31. GER:2b
4 units, Aut (Criddle)

CEE 177S. Design for a Sustainable World—(Graduate students register for 277S.) Technology-based problems faced by developing communities worldwide. Student groups partner with organizations abroad to work on concept, feasibility, design, implementation, and evaluation phases of various projects. Projects this year include a water and health initiative, green school design, seismic safety, and HIV interventions. Admission based on written application and interview; see http://esw.stanford.edu/application.fft before first class for application.
1-5 units, Aut, Win, Spr (Burney, Walewijk)

CEE 178. Introduction to Human Exposure Analysis—(Graduate students register for 276.) Scientific and engineering issues involved in quantifying human exposure to toxic chemicals in the environment. Pollutant behavior, inhalation exposure, dermal exposure, and assessment tools. Overview of the complexities, uncertainties, and physical, chemical, and biological issues relevant to risk assessment. Lab projects. Recommended: MATH 51. GER:2b
3 units, Spr (Leckie)

CEE 179A. Water Chemistry Laboratory—(Graduate students register for 273A.) Laboratory application of techniques for the analysis of natural and contaminated waters, emphasizing instrumental techniques.
2 units, Win (Leckie)

CEE 179B. Process Design for Environmental Biotechnology—(Graduate students register for 275B.) Alternates with 169. Preference to juniors and seniors in CEE. Design of a water or wastewater treatment system using biological processes to remove contaminants. Student teams characterize contaminants in water or wastewater, design and operate bench- and pilot-scale units, and develop a full-scale design. Limited enrollment. Prerequisites: 177, 179A. GER:2b
5 units, Spr (Criddle)

CEE 180. Structural Analysis—Beams, trusses, frames; method of indeterminate analysis by consistent displacement, least work, superposition equations, moment distribution. Matrix methods and computer methods of structural analysis. Prerequisites: 101A, ENGR 14. GER:2b
4 units, Aut (Kiremidjian)

CEE 181. Design of Steel Structures—Concepts of the design of steel structures with a load and resistance factor design (LRFD) approach; types of loading; structural systems; design of tension members, compression members, beams, beam-columns, and connections; and design of trusses and frames. Prerequisite: 180. Corequisite: 181A. GER:2b
3 units, Win (Deierlein)

CEE 181A. Building Design Experience: Steel Structures—Design alternatives through conceptual design; exogenous constraints and execution of one design alternative through design development, using steel structural systems. Prerequisite: 183 or graduate standing. Corequisite: 181.
1 unit, Win (Deierlein)

CEE 182. Design of Reinforced Concrete Structures—Properties of concrete and reinforcing steel; behavior of structural elements subject to bending moments, shear forces, torsion, axial loads, and combined actions; design of beams, slabs, columns and footings; strength design and serviceability requirements; design of simple structural systems for buildings. Prerequisite: 180. Corequisite: 182A. GER:2b
3 units (Krawinkler) not given 2004-05

CEE 182A. Building Design Experience: Reinforced Concrete Structure—Exploration of design alternatives through conceptual design, considering exogenous constraints and execution of one design alternative through design development using reinforced concrete structural systems. Prerequisite: 183 or graduate standing.
1 unit (Krawinkler) not given 2004-05

CEE 183. Introduction to Building Design—Scope of a building design experience; owner, architectural, and MEP constraints; regulatory and social considerations; foundation considerations; structural loading and load paths; thermal loading and heat paths; constructibility issues; and project processes for design and construction. Pre- or corequisites: 101A, 180.
2 units, Aut (Tatum)

CEE 190. Near-Surface Geophysics—(Enroll in GEOPHYS 190.)
3 units, Spr (Knight)

CEE 195. Structural Geology and Rock Mechanics—(Same as GES 111.) Methodology for understanding tectonic processes and their structural products by combining quantitative field data with conceptual and mechanical models of rock deformation and flow. Topics include: mapping techniques using GPS; characterization of structures using differential geometry; dimensional analysis; kinematics of deformation; stress analysis; elasticity, brittle fracture and faulting; viscosity and flow of rock; modeling geological structures using continuum mechanics. Applications include the role of geological structures in the evolution of the earth's crust and the mitigation of geologic hazards. Prerequisites: GES 1, MATH 51, 52. GER:2a
3 units, Win (Pollard)

CEE 196. Engineering Geology Practice—(Same as GES 115.) The application of geologic fundamentals to the planning and design of civil engineering projects. Field exercises and case studies emphasize the impact of site geology on the planning, design, and construction of civil works such as buildings, foundations, transportation facilities, excavations, tunnels and underground storage space, and water supply facilities. Topics: Quaternary history and tectonics, formation and physical properties of surficial deposits, site investigation techniques, geologic hazards, and professional ethics. Prerequisite: GES 1 or consent of instructor. GER:2a
3 units, Spr (Holzer) alternate years, not given 2005-06

CEE 197. Professional Development Seminar—Weekly presentations by practicing engineers on topics relevant to students planning to enter the engineering profession. Environmental, structural, and construction perspectives.
1 unit, Win (Staff)

CEE 198. Directed Reading or Special Studies in Civil Engineering—Written report or oral presentation required. Students must obtain a faculty sponsor.
2-3 units, Aut, Win, Spr, Sum (Staff)

CEE 199. Undergraduate Research in Civil and Environmental Engineering—Written report or oral presentation required. Students must obtain a faculty sponsor.
2-3 units, Aut, Win, Spr, Sum (Staff)

CEE 199H. Undergraduate Honors Thesis—For students who have declared the Civil Engineering B.S. honors major and have obtained approval of a topic for research under the guidance of a CEE faculty adviser. Letter grade only. Written thesis or oral presentation required.
2-3 units, Aut, Win, Spr, Sum (Staff)

PRIMARILY FOR GRADUATE STUDENTS

CEE 200A,B,C. Teaching of Civil and Environmental Engineering—Required of CEE Ph.D. students. Strategies for effective teaching and introduction to engineering pedagogy. Topics: problem solving techniques and learning styles, individual and group instruction, the role of TAs, balancing other demands, grading. Teaching exercises. Register for quarter of teaching assistantship.
1 unit, **A:** *Aut,* **B:** *Win,* **C:** *Spr (Staff)*

CEE 201D. Mathematical Laboratory Applications in Civil and Environmental Engineering—(Undergraduates register for 101D; see 101D.)
2 units, Aut (Kitanidis)

CEE 202. Laboratory Methods in Geophysics—(Enroll in GEOPHYS 162.)
1-3 units, Spr (Prasad)

CEE 203. Probabilistic Models in Civil Engineering—Introduction to probability modeling and statistical analysis in civil engineering. Emphasis is on the practical issues of model selection, interpretation, and calibration. Application of common probability models used in civil engineering including Poisson processes and extreme value distributions. Parameter estimation. Linear regression.
3-4 units, Aut (Menun)

CEE 204. Structural Reliability—Procedures for evaluating the safety of structural components and systems. First-and second-order estimates of failure probabilities of engineered systems. Sensitivity of failure probabilities to assumed parameter values. Measures of the relative importance of random variables. Reliability of systems with multiple failure modes. Reliability updating. Simulation methods and variance reduction techniques. Prerequisite: 203 or equivalent.
3-4 units (Staff) alternate years, given 2005-06

CEE 205. Structural Materials Testing and Simulation—Material failure phenomena such as fracture and plastic yielding in metals and polymeric- and cement-based composites. Material response and behavior presented through experimental observation, theories for predicting response and methods for computational simulation. Practical considerations for material use in civil infrastructure. Lab meetings and group project involving fabrication, experimentation, and simulation of materials.
3-4 units, Win (Billington)

CEE 207A. Energy Resources—(Undergraduates register for 173A; see 173A; same as EARTHSYS 103.)
4-5 units, Aut (Woodward)

CEE 207B. The Coming Energy Revolution—(Undergraduates register for 173B; see 173B.)
4 units (Woodward) not given 2004-05

CEE 207G. Technology Implementation for Sustainable Development in Developing Countries—(Undergraduates register for 173G; see 173G.)
3 units, Win (Gadgil)

CEE 207H. Technologies for Sustainable Societies—Seminar. Technologies that address major societal needs in the context of rapidly growing populations, increasing demands for resources, and stressed local, regional, and global environmental systems. How technologies can contribute to sustainability in buildings, water, food, energy, and transportation. Student presentations.
3 units, Spr (Gadgil)

CEE 215A,B,C,D. Industry Seminar and Internship Program—(Undergraduates register for 115; see 115.)
1 unit, **A:** *Aut: (Clough),* **B:** *Win (Fischer),* **C:** *Spr (Clough),* **D:** *Sum (Staff)*

CEE 222A. Computer Integrated Architecture/Engineering/Construction (A/E/C)—(Undergraduates serve as apprentices, register for 122A.) Crossdisciplinary, collaborative, geographically distributed, project-based, teamwork environment. Round table A/E/C panel discussions, lectures, and labs on collaborative technologies provide a global perspective of the A/E/C industry and cutting edge information technologies. Students exercise theoretical discipline knowledge in architecture, structural, engineering, construction management, and the information technologies in a multidisciplinary context focusing on the concept development phase of a comprehensive building project.
3 units, Win (Fruchter)

CEE 222B. Computer Integrated A/E/C—(Undergraduates serve as apprentices, register for 122B.) Comprehensive team project, including project development and documentation, and final project presentation of product and process. Design and construction alternatives are subject to examination by rapid computational prototyping, concurrent multidisciplinary evaluation, and trade-off analysis. Prerequisite 222A.
2 units, Spr (Fruchter)

CEE 223A. Design and Construction of Steel Structures—Using a 15-story steel building project, students analyze the implications of design decisions on the fabrication and erection of steel structures. Emphasis is on integration of design and construction of different types of steel structures. The implications on structural performance, cost and construction schedule, and evaluation of design alternatives. Economic considerations. Other topics include planning for lead times, floor systems and lateral load resisting systems, composite floor systems, innovative lateral load resisting systems, economics of steel structures,

design and construction of steel connections, implication of design decisions related to welding and bolting. Prerequisite: 181 or equivalent.
3 units, Aut (Miranda)

CEE 223B. Design and Construction of Concrete Structures—How to evaluate the implications of design decisions in structural performance, cost, and construction schedule of concrete structures. Emphasis is on integration of design and construction of concrete structures and economic considerations. Reinforced and pre-stressed concrete structures. Evaluation of design alternatives. Economic considerations in selecting floor systems and lateral resisting systems for buildings. Design and construction of beams, one-way and post-tensioned slabs, structural walls, coupled structural walls. Precast and post-tensioned elements, and connections in precast elements. Prerequisite: 182 or equivalent.
3 units, Win (Miranda)

CEE 224. Preconstruction Planning for Design/Construction Integration—Overview of marketing, planning commission, fire and building codes, team building, schedule development, and budget development using the design construction integration approach. Topics are explored using various types of projects (entertainment, museums, educational, high-tech, semi-conductor, housing, biotech).
3 units, Win (Spradlin)

CEE 237. Introduction to Biotechnology—(Enroll in CHEMENG 450, BIOC 450.)
3 units, Spr (Staff)

CEE 238. Frontiers in Interdisciplinary Biosciences—(Crosslisted in departments in the schools of H&S, Engineering, and Medicine; student register through their affiliated departments; otherwise register for CHEMENG 459) See CHEMENG 459 or http://biox.stanford.edu/courses/459_announce.html.
1 unit, Aut, Win, Spr (Robertson)

CEE 240. Analysis and Design of Construction Operations—Planning and management of construction work at the field operations level. Data collection, analysis, modeling, and design. Emphasis is on work methods development, productivity, safety, and total quality management. Requires four full days on Friday, working on a local residential building project to gain experience with concepts taught in class.
4 units (Paulson) not given 2004-05

CEE 241. Techniques of Project Planning and Control—Fundamental concepts of project planning and control; current and future project information technologies; project planning and control systems at the firm and project level. Topics: cost estimating at conceptual, schematic, detailed, and bid stages, measurement and pricing of work; work breakdown structures; planning and scheduling techniques, including CPM, PERT, LOB; resource allocation; project control; supply chain models; treatment of uncertainty; virtual design and construction, electronic integration of time and cost planning and control, and 4D modeling. Group term project including technical report and presentation. Prerequisite: 100 or equivalent, or consent of instructor.
3-4 units, Win (Fischer)

CEE 242. Organization Design for Projects and Companies—Introduction to organizational behavior. Information-processing theory of organizational design for projects and companies and computer-based organizational analysis tools. Groups of 12 students practice running problem-focused meetings. Case studies focus on facility/product design and construction/manufacturing organizations; concepts are applicable to project-focused teams and companies in all industries.
4 units, Aut (Levitt)

CEE 243. Virtual Design and Construction—(Undergraduates register for 143; see 143.)
3-4 units, Win (Kunz)

CEE 244A. Fundamentals of Construction Accounting and Finance—Introduces the concepts and fundamentals of financial accounting and economics in general, and specifically in the construction industry. Financial statement understanding and analysis, accounting concepts, project accounting methods, and the nature of project costs. Case study of major construction contractor. Ownership structure, working capital, and the sources and uses of funds.
2 units, Aut (Tucker, Meyer)

CEE 244B. Advanced Construction Accounting, Financial Issues, and Claims—Continuation of 244A. Emphasis is on advanced construction accounting and economic issues, the recovery of project overruns, and construction industry financial disclosures. Construction claims, project cost overrun analysis, and cost recovery methods related to: labor, equipment, indirect costs, overhead, cost of capital, and profit claims. Schedule delay analysis in the context of claims.
2 units, Win (Tucker, Meyer)

CEE 245. International Construction Management—Introduction to management tools for strategy, structure, personnel, and culture of global projects. International construction markets, major players, financing, and joint ventures. All phases of the life cycle of global projects: prequalification, bid preparation, contract negotiations, joint venture agreements, startup of projects, execution of work, and closure. Case studies to develop a model of international construction joint ventures.
3 units, Win (Brockmann)

CEE 246. Managing Engineering and Construction Companies—Management of design and construction companies in the architecture-engineering-construction industry. Focus is on management of risks inherent in the A/E/C industry: developing business strategies and organizations to cope with cyclical demand, alternative contracting approaches, managing receivables and cash flow, administration of human resources, safety, quality, insurance, and bonding. Students play different management roles in a computer simulation of a construction company. Prerequisites: introductory accounting course such as ENGR 60, CEE 244A, or MS&E 140.
4 units, Spr (Levitt)

CEE 247. Cases in Personality, Leadership, and Negotiation—(Undergraduates register for 147; see 147.)
4 units, Spr (Clough)

CEE 248. Real Estate Development—Overview of the real estate development process emphasizing critical activities and key participants. Topics: conceptual and feasibility studies, market perspectives, the public roles, steps for project approval, project finance, contracting and construction, property management, and sales. Group term projects focus on actual developments now in the planning stage. Enrollment limited to 18 students with priority to graduate majors in the department's CEM or DCI programs. Prerequisites: 241, 244A or equivalent, ENGR 60.
3 units, Spr (Kroll)

CEE 249. Labor and Industrial Relations in Construction—The history, laws, institutions, and social and economic forces affecting labor and industrial relations in construction, covering the union and open shop sectors. Comparative labor relations (other nations), simulated collective bargaining and arbitration exercises; field trip.
2 units, Spr (Walton)

CEE 251. Negotiation—(Undergraduates register for 151, see 151; same as MS&E 285, ME 207.)
3 units, Aut, Spr (Christensen)

CEE 252. Construction Engineering for Concrete and Steel Structures—Technical overview of materials, methods and field operations required for construction of steel and concrete structures. Steel work includes detailing, fabricating, erecting, connecting. Concrete work includes batching, transporting, placing, finishing, curing and formwork. Introduction to activities required to provide technical support for field operations Group analysis of technical operation or support activity.
4 units, Win (Tatum)

CEE 253. Construction Equipment and Methods—Methods and machinery to build projects planned by engineers and architects. Application of engineering fundamentals to the selection and design of equipment and systems to carry out production operations in construction; analysis of production output and costs; application of engineering economy to equipment and process decision making. Prerequisites: 100, and ENGR 60, PHYSICS 21 or 53.
3-4 units, Spr (Staff)

CEE 254. Cases in Estimating Costs—(Undergraduates register for 154; see 154.)
3 units, Aut (Clough)

CEE 256. Building Systems—(Undergraduates register for 156; see 156.) Corequisite for graduate students: 256A.
3 units, Win (Staff)

CEE 256A. Building System Design Experience—Graduate students engage in group project involving analysis of design and construction for a building system. Corequisite: 256.
1 unit, Win (Staff)

CEE 257. Building Better: Technical and Sustainable Construction—Technical overview of design and construction for high tech facilities and sustainable construction operations. High tech includes high purity systems, cleanrooms, control systems, laboratories, biotech plants, and semiconductor fabs. Sustainable construction includes permit requirements, green materials and operations, and compliance programs and monitoring. Field trips and reports; group analysis of technical project, system, or sustainable operations.
3 units, Spr (Tatum)

CEE 258A,B,C. Donald R. Watson Seminar in Construction Engineering and Management—Required of graduate students in the CEM program; all students including undergraduates welcome. Weekly interactions and discussions with speakers from industry and government.
1 unit, **A:** *Aut (Clough),* **B:** *Win (Fischer),* **C:** *Spr (Clough)*

CEE 259A,B,C. Construction Problems—Analysis of group-selected problems in construction techniques, equipment, or management, followed by preparation of oral and/or written reports. Students consult specialists from the construction industry and make use of University facilities. See 299 for individual studies. Prerequisites: graduate standing in CEM program and consent of instructor.
1-3 units, Aut, Win, Spr (Staff)

CEE 260A. Physical Hydrogeology—(Same as GES 230.) Theory of underground water, analysis of field data and pumping tests, geologic groundwater environments, solution of field problems, groundwater modeling. Introduction to groundwater contaminant transport and unsaturated flow. Lab. Prerequisite: elementary calculus.
4 units, Aut (Gorelick)

CEE 260B. Surface and Near-Surface Hydrologic Response—(Same as GES 237.) Quantitative review of process-based hydrology and geomorphology. Introduction to finite-difference and finite-element methods of numerical analysis. Topics: biometeorology, unsaturated and saturated subsurface fluid flow, overland and open channel flow, erosion and mass wasting, and physically-based simulation of coupled surface and near-surface hydrologic response and landscape evolution. Links hydrogeology, soil physics, and surface water hydrology.
4 units, Aut (Loague) alternate years, not given 2005-06

CEE 260C. Contaminant Hydrogeology—(Same as GES 231.) For earth scientists and engineers. Environmental and water resource problems involving contaminated groundwater. The processes affecting contaminant migration through porous media including interactions between dissolved substances and solid media. Conceptual and quantitative treatment of advective-dispersive transport with reacting solutes. Predictive models of contaminant behavior controlled by local equilibrium and kinetics. Modern methods of contaminant transport simulation and optimal aquifer remediation. Prerequisite: 260A or GES 230 or equivalent.
4 units, Spr (Staff)

CEE 262A. Hydrodynamics—The flow of incompressible viscous fluid; emphasis is on developing an understanding of fluid dynamics that can be applied to environmental flows. Topics: kinematics of fluid flow; equations of mass and momentum conservation (including density variations); some exact solutions to the Navier-Stokes equations; appropriate analysis of fluid flows including Stokes flows, potential flows, and laminar boundary layers; and an introduction to the effects of rotation and stratification through scaling analysis of fluid flows. Prerequisites: 101B or consent of instructor; and some knowledge of vector calculus and differential equations.
3-4 units, Aut (Monismith)

CEE 262B. Transport and Mixing in Surface Water Flows—Application of fluid mechanics to problems of pollutant transport and mixing in the water environment. Mathematical and numerical models of advection, diffusion, and dispersion. Application of theory to problems of transport and mixing in rivers, estuaries, and lakes and reservoirs. Recommended: 262A and CME 102 (formerly ENGR 155A) or equivalents.
3-4 units, Win (Monismith)

CEE 262D. Introduction to Physical Oceanography—(Undergraduate students register for 164; see 164; same as EARTHSYS 164.)
4 units, Win (Fong)

CEE 263A. Air Pollution Modeling—Introduction to the numerical modeling of urban, regional, and global air pollution with a focus on gas chemistry and radiative transfer. Stratospheric, free-tropospheric, and urban chemistry. Methods for solving stiff systems of chemical ordinary differential, including the Multistep Implicit-Explicit method, Gear's method with sparse-matrix techniques, and the family method. Numerical methods of solving radiative transfer, coagulation, condensation, and chemical equilibrium problems. Project involves the development of a basic chemical ordinary differential equation solver. Prerequisite: CS 106A or equivalent.
3-4 units (M. Jacobson) not given 2004-05

CEE 263B. Numerical Weather Prediction—Introduction to numerical weather prediction. Continuity equations for air and water vapor, the thermodynamic energy equation, and momentum equations are derived for the atmosphere. Numerical methods of solving partial differential equations, including finite-difference, finite-element, semi-Lagrangian, and pseudospectral methods. Time-stepping schemes: the forward-Euler, backward-Euler, Crank-Nicolson, Heun, Matsuno, leapfrog, and Adams-Bashforth schemes. Boundary-layer turbulence parameterizations, soil moisture, and cloud modeling. Project developing a basic mesoscale model. Prerequisite: CS 106A or equivalent.
3-4 units, Win (M. Jacobson)

CEE 263C. Weather and Storms—(Undergraduates register for 63; see 63.)
3 units, Aut (M. Jacobson)

CEE 263D. Air Pollution: From Urban Smog to Global Change—(Undergraduates register for 64; see 64.)
3 units, Spr (M. Jacobson)

CEE 264A. Rivers, Streams, and Canals—(Undergraduates register for 161A; see 161A.)
3-4 units, Aut (Street)

CEE 265A. Sustainable Water Resources Development—Alternative criteria for judging the sustainability of projects. Application of criteria to evaluate sustainability of water resources projects in several countries. Case studies illustrate the role of political, social, economic, and environmental factors in decision making. Evaluation of benefit-cost analysis and environmental impact assessment as techniques for enhancing the sustainability of future projects. Limited enrollment. Prerequisite: graduate standing in Environmental and Water Studies, or consent of instructor.
3 units, Spr (Staff)

CEE 265B. Privatization of Water Supply and Sanitation—Theory and practice of private sector participation in the water and sanitation sector in developing and industrialized countries, and its effects on efficiency, customer responsiveness, risk allocation, equity, and environment. Objectives, strengths, and weaknesses of alternative arrangements including small-scale independent providers and large-scale concession agreements. Case studies. Limited enrollment. Prerequisites: familiarity with water and sanitation sector or public service delivery, and consent of instructor.
3 units, Aut (Davis)

CEE 266A. Watersheds and Wetlands—(Undergraduates register for 166A; see 166A.)
3 units, Aut (Freyberg)

CEE 266B. Floods and Droughts, Dams and Aqueducts—(Undergraduates register for 166B; see 166B.)
3 units, Win (Freyberg)

CEE 266D. Water Resources and Water Hazards Field Trips—(Undergraduates register for 166D; see 166D.)
2 units, Win (Freyberg)

CEE 267. Data Analysis and Uncertainty—Probabilistic and statistical methods with emphasis on basic concepts and tools, illustrated with applications from environmental and water studies. Topics: exploratory data analysis; probability theory; classical statistics; Bayesian statistics; geostatistics; and inverse problems.
3 units, Spr (Kitanidis)

CEE 268. Groundwater Flow—Study of flow and mass transport in porous media through analytical techniques. Applications of potential flow theory to practical groundwater problems: flow to and from wells, rivers, lakes, drainage ditches; flow through and under dams; streamline tracing; capture zones of wells; and mixing schemes for in-situ remediation. Prerequisites: calculus and introductory fluid mechanics.
3-4 units, Win (Kitanidis)

CEE 269. Environmental Fluid Mechanics and Hydrology Seminar—Problems in all branches of water resources, with talks by visitors, faculty, and students.
1 unit, Spr (Monismith)

CEE 270. Movement and Fate of Organic Contaminants in Waters—Transport of chemical constituents in surface and groundwater including advection, dispersion, sorption, interphase mass transfer, and transformation; impacts on water quality. Emphasis is on physicochemical processes and the behavior of hazardous waste contaminants. Prerequisites: undergraduate chemistry and calculus. Recommended: 101B.
3 units, Aut (Luthy)

CEE 271A. Physical and Chemical Treatment Processes—Physical and chemical unit operations for water treatment, emphasizing process combinations for drinking water supply. Application of the principles of chemistry, rate processes, fluid dynamics, and process engineering to define and solve water treatment problems by flocculation, sedimentation, filtration, disinfection, oxidation, aeration, and adsorption. Investigative paper on water supply and treatment. Prerequisites: 101B, 270. Recommended: 273.
3 units, Win (Luthy)

CEE 271B. Environmental Biotechnology—Stoichiometry, kinetics, and thermodynamics of microbial processes for the transformation of environmental contaminants. Design of dispersed growth and biofilm-based processes. Applications include treatment of municipal and industrial waste waters, detoxification of hazardous chemicals, and groundwater remediation. Prerequisites: 270; 177 or 274A or equivalents.
4 units, Win (Criddle)

CEE 272. Coastal Contaminants—Coastal pollution and its effects on ecosystems and human health. The sources, fate, and transport of human pathogens, nutrients, heavy metals, persistent organics, endocrine disrupters, and toxic algae. Background on coastal ecosystems and coastal transport phenomena including tides, waves, and cross shelf transport. Undergraduates may enroll with consent of instructor.
4 units, Win (Boehm)

CEE 273. Aquatic Chemistry—Chemical principles and their application to the analysis and solution of problems in aqueous geochemistry (temperatures near 25 C and atmospheric pressure). Emphasis is on the analysis of natural water systems and the understanding and solution of specific chemical problems in water purification technology and water pollution control. Prerequisites: CHEM 31 and 33, or equivalents.
3 units, Aut (Leckie)

CEE 273A. Water Chemistry Laboratory—(Undergraduates register for 179A; see 179A.)
2 units, Win (Leckie)

CEE 274A. Environmental Microbiology I—The fundamental aspects of microbiology and biochemistry. The biochemical and biophysical principles of biochemical reactions, energetics, and mechanisms of energy conservation. Diversity of microbial catabolism, flow of organic matter in nature: the carbon cycle, and biogeochemical cycles. Bacterial physiology, phylogeny, and the ecology of microbes in soil and marine sediments, bacterial adhesion, and biofilm formation. Microbes in the degradation of pollutants. Prerequisites: CHEM 33, 35, and BIOSCI 41, or equivalents.
3 units, Aut (Spormann), Sum (Staff)

CEE 274B. Environmental Microbiology II—Microbial biochemistry of organic pollutant degradation. Metabolic logic of biochemical pathways and predicting biodegradation. Metabolic ecology: reciprocal interactions of microbial activities and the environment. Microbial biofilms and biofilm communities. Cell-cell communication and gene transfer. Constructing microbial biofilms for pollutant degradation. Mechanisms of molecular evolution. Genomic evolution and microbial ecology. Detection of microorganisms in the environment (gene probes, immuno probes, enzyme probes). Prerequisite: 274A.
3 units, Win (Spormann)

CEE 274C. Environmental Microbiology Laboratory—Microbiological and molecular techniques for characterizing microbes. Enrichment and isolation of microbes from their natural environment. Determination of growth parameters. Visualizing microbes in biofilms. Detection of microbes in the environment. Horizontal gene transfer and evolution of microbes with new metabolic capacity. Prerequisites: 274A,B.
3 units, Spr (Spormann)

CEE 274D. Pathogens and Disinfection—Introduction to epidemiology, major pathogens and infectious diseases, the immune system, movement and survival of pathogens in the environment, transfer of virulence and antibiotic resistance genes, and pathogen control, with an emphasis on public health engineering measures (disinfection). Prerequisite: 274A.
3 units (Criddle) not given 2004-05

CEE 274E. Pathogens in the Environment—Sources, fates, movement, and ecology of waterborne pathogens in the natural environment and disinfection systems. Epidemiology and microbial risk assessment. Focus is on human virus, bacteria, and protists. How to evaluate peer-reviewed papers. No microbiology background required; undergraduates may enroll with consent of instructor.
3 units, Spr (Boehm)

CEE 275B. Process Design for Environmental Biotechnology—(Undergraduates register for 179B; see 179B.)
5 units, Spr (Criddle)

CEE 276. Introduction to Human Exposure Analysis—(Undergraduates register for 178; see 178.)
3 units, Spr (Leckie)

CEE 277S. Design for a Sustainable World—(Undergraduates register for 177S; see 177S.)
1-5 units, Aut, Win, Spr (Burney, Walewijk)

CEE 278A. Air Pollution Physics and Chemistry—The sources and health effects of pollutants. The influence of meteorology on pollution: atmospheric energy balance, temperature profiles, stability classes, inversion layers, turbulence. Atmospheric diffusion equations, downwind dispersion of emissions from point and line sources. Tropospheric chemistry: mechanisms for ozone formation, photochemical reactions, radical chain mechanisms, heterogeneous chemical reactions. Prerequisites: MATH 51, CHEM 31, or equivalents. Recommended: 101B, 273 or CHEM 135, or equivalents.
3 units, Aut (Hildemann)

CEE 278B. Atmospheric Aerosols—The characterization of atmospheric particulate matter: size distributions, chemical composition, health effects. Atmospheric diffusion and transport of particles: removal by convection, impaction, gravitational settling. Effect of aerosols on visibility: light scattering and absorption, reduction of visual range. Mechanics influencing ambient size distributions: Brownian coagulation, laminar shear flow, homogeneous nucleation, heterogeneous condensation. Prerequisite: MATH 51, or equivalent. Recommended: 101B or equivalent.
3 units, Spr (Hildemann)

CEE 279. Environmental Engineering Seminar—Current research, practice, and thinking in environmental engineering and science. Attendance at seminars is self-directed, and may be accrued throughout the school year. See instructor for syllabus.
1 unit, Spr (Staff)

CEE 280. Advanced Structural Analysis—Theoretical development and computer implementation of direct stiffness method of structural analysis; virtual work principles; computation of element stiffness matrices and load vectors; direct assembly procedures; equation solution techniques. Analysis of two- and three-dimensional truss and frame structures, thermal loads, and substructuring and condensation techniques for large systems. Practical modeling techniques and programming assignments. Introduction to nonlinear analysis concepts. Prerequisites: elementary structural analysis and matrix algebra.
3-4 units, Aut (Deierlein)

CEE 281. Finite Element Structural Analysis—Formulation and implementation of frame, plane stress, plane strain, axisymmetric, torsional, solid, plate, and shell elements. Topics: strong and weak forms of the problem, variational principles and the principle of minimum potential energy, the finite element method as an extension of the Rayleigh-Ritz methods, shape functions, isoparametric mapping, numerical integration, convergence requirements, and error estimation. Techniques for application to modeling structural systems. Prerequisite: 280 or equivalent.
3 units, Win (Staff)

CEE 282. Nonlinear Structural Analysis—Introduction to methods of geometric and material nonlinear analysis, emphasizing modeling approaches for framed structures. Large-displacement analysis, concentrated and distributed plasticity models, and nonlinear solution methods. Applications to frame stability and performance-based seismic design. Assignments emphasize computer implementation and applications. Prerequisites: 280, 286 or equivalent.
3 units, Spr (Deierlein)

CEE 283. Structural Dynamics—Vibrations and dynamic response of simple structures under time dependent loads; dynamic analysis of single and multiple degrees of freedom systems; support motion; response spectra.
3-4 units, Aut (Law)

CEE 284. Computational Methods in Structural Dynamics—Methods of structural dynamics for discretized and continuous systems in free and forced vibration, modal analysis; numerical methods; introduction to nonlinear dynamics; advanced topics. Prerequisites: 280, 283.
3 units (Law) alternate years, given 2005-06

CEE 285. Behavior of Structural Systems for Buildings—Basic design concepts, performance criteria, loading, methods of design, types of structural systems, behavior under gravity and lateral loads, approximate methods of analysis, preliminary conceptual design, performance assessment, behavior of structural elements. Prerequisites: basic courses in design of steel and reinforced concrete structures.
3-4 units, Win (Krawinkler)

CEE 286. Advanced Structural Design—Strength, stiffness, and ductility considerations in the design of structural elements and systems made of steel, reinforced concrete, and other materials. Concepts of redistribution and strength of structures (element versus system behavior). Design of two-way slab systems. Prerequisites: basic courses in design of steel and reinforced concrete structures.
3-4 units, Aut (Krawinkler)

CEE 287. Earthquake Resistant Design and Construction—Evaluation, design, and construction of structures in seismic regions. Factors influencing earthquake ground motions, design spectra, design of linear and nonlinear single- and multiple-degree-of-freedom-system structures, design of structures to minimize damage, force-based and displacement-based design methods, capacity design, detailing and construction of steel and reinforced concrete structures, performance-based design, seismic isolation, and energy dissipation. Prerequisites: 283, 285. Recommended: 286, 288.
3 units, Spr (Miranda)

CEE 288. Earthquake Hazard and Risk Analysis—Earthquake phenomena, faulting, ground motion, study of past major earthquakes, effects of earthquakes on manmade structures, response spectra, Fourier spectra, power spectra, soil effects on ground motion and structural damage, methods for structural damage evaluation, current research in earthquake engineering. Prerequisites: 203, 283.
3 units, Win (Kiremidjian)

CEE 289. Random Vibrations—Introduction to random processes. Correlation and power spectral density functions. Stochastic dynamic analysis of multi-degree-of-freedom structures subjected to stationary and non-stationary random excitations. Crossing rates, first-excursion probability, and distributions of peaks and extremes. Applications in earthquake, wind, and ocean engineering. Prerequisite: 203 or equivalent.
3-4 units (Staff) not given 2004-05

CEE 290. Structural Performance and Failures—Basic concepts in the definition of satisfactory structural performance; key elements in structural performance; types of failures, ranging from reduced serviceability to total collapse; failure sources and their root cause allocation, emphasizing design/construction process failures; failure prevention mechanisms; illustration with real life examples.
2 units, Spr (Moncarz)

CEE 291. Advanced Structural Concrete Modeling and Design—Emphasis is on prestressed concrete bridge design. Basic concepts of strut and tie modeling, prestressed concrete design, and design and behavior of concrete box girder bridges. Introduction to innovative precast systems for bridge design. Course project integrating computer simulation and physical experimentation of a structural concrete subassembly designed using the strut and tie method.
3 units, Spr (Billington)

CEE 292. Computer Methods in Structural Engineering—Basic techniques for the development of structural engineering analysis and design software. Topics: basic data structure; computer representation of engineering systems; implementation of advanced numerical methods and engineering software; automated conformance checking of design codes and standards. Prerequisites: CS 106A or equivalent.
3 units, Win (Law)

CEE 293. Foundation Engineering—Types, characteristics, analysis, and design of shallow and deep foundations; rigid and flexible retaining walls; braced excavations; settlement of footings in sands and clays; slope stability analysis by method of slices including search algorithms for the critical slip surface. Special seminars by guest speakers; computing assignment. Prerequisite: 101C or equivalent.
3 units, Win (Borja)

CEE 294. Computational Geomechanics—Continuum and finite element formulations of steady-state and transient fluid conduction problems in geomechanics; elliptic, parabolic, and hyperbolic systems; variational inequality and free-boundary problems; three-dimensional consolidation theory; undrained condition, mesh locking, B-bar and strain projection methods; finite element formulations of multiphase dynamic problems. Computing assignments. Prerequisite: ME 335A or equivalent.
3 units (Borja) alternate years, given 2005-06

CEE 295. Plasticity Modeling and Computation—Theory of plasticity; micromechanical basis; classical yield models; return-mapping algorithm; multi-surface and bounding surface models; material instabilities; localization and bifurcation. Prerequisite: ME 338A or equivalent.
3 units, Spr (Borja) alternate years, not given 2005-06

CEE 296. Modeling of Models in Geotechnical Engineering—Physical and numerical modeling in geomechanics. Primitive geotechnical models illustrate three-dimensional seepage and strain localization in simple shear and triaxial devices. Finite element modeling and simulations conducted using ANSYS. Numerical simulations demonstrate the 3D, solid-mesh generation capabilities of the program and the limitations of deformation analysis in the softening regime. Prerequisite: 101C or equivalent. Corequisite: course in finite element method.
2 units, Win (Borja)

CEE 297. Issues in Geotechnical and Environmental Failures—Causes and consequences of the failure of buildings, earth structures, waste storage, and high hazard facilities in contact with the environment; technical, ethical, economic, legal, and business aspects; failure analysis and forensic problems; prevention, liability, and dispute management. Case histories including earthquake, flood, and hazardous waste facilities. Student observation, participation in active lawsuits where possible.
3 units, Aut (Meehan)

CEE 297G. Advanced Structural Geology and Rock Mechanics—(Same as GES 215.) Solutions to initial and boundary-value problems of continuum mechanics integrated with quantitative field and laboratory data to develop conceptual and computational models for tectonic processes and the development of geological structures. Topics include: techniques for structural mapping and data analysis; differential geometry to characterize structures; dimensional analysis and scaling relations; kinematics of deformation and flow; traction and stress analysis; conservation laws; mechanical properties of rock (elasticity, viscosity, strength, friction, fracture toughness). Models formulated and solutions visualized using MATLAB. Prerequisites: GES 1, calculus, MATLAB or equivalent.
3-5 units, Aut (Pollard)

CEE 298. Structural Engineering and Geomechanics Seminar—Recommended for all graduate students. Lectures on topics of current interest in professional practice and research.
1 unit, Win (Staff)

CEE 299. Independent Study in Civil Engineering—Directed study for graduate students on subjects of mutual interest to students and faculty. Student must obtain faculty sponsor.
1-3 units, Aut, Win, Spr, Sum (Staff)

CEE 300. Thesis (Engineer Degree)—Research by Engineer candidates.
1-15 units, Aut, Win, Spr, Sum (Staff)

CEE 310. Post-Master's Seminar—For post-master's students to serve as orientation to the selection of a research topic.
1 unit, Aut, Win, Spr (Staff)

CEE 316. Research Methods in Facility Engineering—For CEE Ph.D. students interested in facility planning, design, management, and operation. Research philosophy and methods seminar. Experimental design: ethnography, case study, survey, classical experiment (natural, synthetic, or computational). Data analysis: ANOVA, regression, correlation. Introduction to modeling social systems. Publication strategies. Final project to develop and refine research proposal and publication plan.
3-4 units (Levitt) alternate years, given 2005-06

CEE 320. Integrated Facility Engineering—Individual and group presentations on goals, research, and state-of-practice of virtual design and construction in support of integrated facility engineering, including objectives for the application and further development of virtual design and construction technologies.
1 unit, Aut, Spr (Kunz, Fischer)

CEE 333. Water Policy Seminar—(Same as IPER 333.) Student-organized interdisciplinary seminar. Focus is on creation, implementation, and analysis of policy affecting the use and management of water resources. Weekly speakers from academia and local, state, national, and international agencies and organizations. Previous topics include water policy in California and developing countries.
1 unit, Spr (Freyberg)

CEE 342. Computational Modeling of Organizations—For post-M.S. students interested in formal techniques for organization design. Computer simulation of organizations are used to conduct virtual experiments for developing organization theory or to analyze the performance of virtual organizations with different structures and decision support and communication technologies. Goals: introduce research on computational modeling and design of real-world organizations. Paper serves as a research proposal. Prerequisite: 242 or equivalent introductory organization design class.
4 units, Win (Levitt) alternate years, not given 2005-06

CEE 362A. Advanced Topics in Mathematical Analysis of Flow Transport—Topics vary each year and include vector and tensor analysis, perturbation and asymptotic methods, Lagrangian methods such as particle tracking and travel-time solutions, and selected numerical methods for flow and transport problems.
1 unit, Aut (Kitanidis)

CEE 363A. Mechanics of Stratified Flows—(Formerly 363.) The effects of density stratification on flows in the natural environment. Basic properties of linear internal waves in layered and continuous stratification. Flows established by internal waves. Internal hydraulics and gravity currents. Turbulence in stratified fluids. Prerequisites: 262A,B, CME 204 (formerly ME 300B).
3 units (Fong) alternate years, given 2005-06

CEE 363B. Geophysical Fluid Dynamics—(Formerly 364B.) Focus is on fluid dynamics of the ocean at scales where the influence of the earth's rotation is important. Topics include geostrophic and quasi-geostrophic flows, planetary waves, potential vorticity, the Rossby adjustment problem, effects of stratification, and flows on the sea plane. Hydrodynamic stability of rotating and stratified flows. Prerequisite: 363A.
3 units (Fringer) alternate years, given 2005-06

CEE 363C. Ocean and Estuarine Modeling—Advanced topics including methods for the shallow water, primitive, and nonhydrostatic equations on Cartesian, curvilinear, and unstructured finite-volume grid systems. Free-surface methods, nonhydrostatic solvers, and advanced Eulerian and Lagrangian advection techniques. Focus is on studies of existing techniques and code packages and their methodologies including POM, ROMS, TRIM, ELCOM, and STUNTANS. Problem sets and final project. Prerequisite: CME 204 (formerly ME 300B) or equivalent.
3 units, Aut (Fringer) alternate years, not given 2005-06

CEE 365A,B,C,D. Advanced Topics in Environmental Fluid Mechanics and Hydrology—Students must obtain a faculty sponsor.
2-6 units, **A:** *Aut,* **B:** *Win* **C:** *Spr,* **D:** *Sum (Staff)*

CEE 370A,B,C,D. Environmental Research—For first-year Ph.D. students in the Environmental Engineering and Science program. 15-18 hours/week on research over three quarters. 370A requires written literature survey on a research topic; 370B requires oral presentation on experimental techniques and research progress; 370C requires written or oral presentation of preliminary doctoral research proposal. Students must obtain a faculty sponsor.
5-6 units, **A:** *Aut,* **B:** *Win,* **C:** *Spr,* **D:** *Sum (Staff)*

CEE 371. Frontiers in Environmental Research—How to evaluate environmental research.
1-2 units, Aut, Win, Spr (Spormann)

CEE 372. Environmental Mass Transfer—Mass transport physics and mathematics. Focus is on environmental engineering applications including chemical sorption, biofilm growth, aggregate formation, and pollutant transport in rivers, lakes, and oceans.
3 units (Boehm) not given 2004-05

CEE 376. Organic Analyses in Environmental Sciences—Theory and practice of instrumental methods used in environmental engineering and sciences, emphasizing determination of organic substances by gas chromatography, mass spectrometry, and high pressure liquid chromatography. Interpretation of mass spectra adaptation of techniques to specific environmental matrices. Case studies.
2-3 units, Spr (Reinhard)

CEE 377. Research Proposal Writing in Environmental Engineering and Science—For first- and second-year post-master's students preparing for thesis defense. Students develop progress reports and agency-style research proposals, and present a proposal in oral form. Prerequisite: consent of thesis adviser.
1-3 units, Aut, Win, Spr, Sum (Staff)

CEE 398. Report on Civil Engineering Training—On-the-job training under the guidance of experienced, on-site supervisors; meets the requirements for Curricular Practical Training for students on F-1 visas. Students submit a concise report detailing work activities, problems worked on, and key results. Prerequisite: qualified offer of employment and consent of adviser as per I-Center procedures.
1 unit, Aut, Win, Spr, Sum (Staff)

CEE 399. Advanced Engineering Problems—Individual graduate work under direction of a faculty sponsor on a subject of mutual interest. Written report usually required.
1-5 units, Aut, Win, Spr, Sum (Staff)

CEE 400. Thesis (Ph.D. Degree)—For students who have successfully completed the department general qualifying examination. Research and dissertation for the Ph.D. degree.
1-15 units, Aut, Win, Spr, Sum (Staff)

OVERSEAS STUDIES

These courses are approved for the Civil and Environmental Engineering major and taught overseas at the campus indicated. Students should discuss with their major advisers which courses would best meet individual needs. Descriptions are in the "Overseas Studies" section of this bulletin, or at the Overseas Studies Office, 126 Sweet Hall.

SANTIAGO

CEE 33X. The Built Environmental History of Chile
3 units, Spr (Kunz)

CEE 143X. Virtual Design and Construction: Visualizing a 50-Year Evolution of the Heart of Santiago
4 units, Spr (Kunz)

This file has been excerpted from the *Stanford Bulletin, 2004-05*, pages 126-140. Every effort has been made to ensure accuracy; post-press changes may have been made here. Contact the editor of the bulletin at arod@stanford.edu with changes or corrections. See the bulletin website at http://bulletin.stanford.edu for late changes.