Structural Engineering (SE)

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Structural Engineering is the branch of engineering concerned with the design and analysis of civil, mechanical, aerospace, marine, naval and offshore structures. It requires knowledge and competence in the areas of materials, response of individual structural components and the behavior of entire structural systems.

Department Focus

The instructional and research programs of the department are grouped into four programmatic focus areas: civil structures, aerospace and composite structures, renewal of structures, and earthquake engineering. Both the undergraduate and graduate programs are characterized by strong interdisciplinary relationships with the Departments of Mechanical and Aerospace Engineering, Physics, Mathematics, Bioengineering, Chemistry, Electrical and Computer Engineering, Computer Science and Engineering, the Materials Science Program, and associated campus institutes such as the Institute of Geophysics and Planetary Physics, Institute for Pure and Applied Physical Sciences, Institute for Biomedical Engineering, Center of Excellence for Advanced Materials, California Space Institute, Calit2, and Scripps Institution of Oceanography.

The programs and curricula of the Department of Structural Engineering will educate and train engineers in a holistic approach to structural systems engineering by emphasizing and building on the commonality of engineering structures in materials, mechanics, analysis and design across the engineering disciplines of civil, aerospace, marine and mechanical engineering.

Although structural engineering is traditionally viewed as an activity within civil engineering, in actuality many other engineering disciplines such as aerospace, marine (naval, offshore), and mechanical engineering contain well established discipline-specific structural systems and components. In all of the various engineering disciplines there exists a large commonality in the structural materials used, in the general principles of structural mechanics, in the overall design philosophy and criteria, and in the modeling and analysis tools employed for the numerical quantification and visualization of structural response. Particularly, small disciplinary differences in materials and computational tools are rapidly disappearing with the civil engineering community opening up to new structural materials developed and used to date primarily in the aerospace industry, and with computational developments which are less product specific but more geared towards a holistic structural systems design approach with interactive graphics, object-oriented database management and concurrent visualization and data processing. Developments in overall structural systems design are increasingly cross-disciplinary over many traditional engineering areas.

The Undergraduate Program

Degree and Program Options

The Department of Structural Engineering offers an unique engineering program leading to the B.S. degree in structural engineering which is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC/ABET). The Department of Structural Engineering also offers a nonaccredited B.S. degree in engineering sciences. The B.S. programs require a minimum of 148 units, plus college requirements in humanities and social sciences.

All Structural Engineering programs of study have strong components in laboratory experimentation, numerical computation, and engineering design. Design is emphasized throughout the curricula by open-ended homework problems, by laboratory and computer courses which include student-initiated projects, and finally, by senior design project courses which involve teams of students working to solve engineering design problems brought in from industry. The Structural Engineering programs are designed to prepare students receiving bachelor's degrees for professional careers or for graduate education in their area of specialization. In addition, the programs can also be taken by students who intend to use their undergraduate engineering education as preparation for postgraduate professional training in non-technical fields such as business administration, law or medicine.

Structural Engineering is concerned with the design and analysis of civil, mechanical, aerospace, marine, naval, and offshore structures. Examples include bridges, dams, buildings, aircraft, spacecraft, ships, oil platforms, automobiles, and other transportation vehicles. This field requires a thorough knowledge of the behavior of solids (concrete, soils, rock, metals, plastics, and composite materials), fluid mechanics as it relates to structural loads, dynamics as it relates to structural response, mathematics for the generation of theoretical structural models and numerical analysis, and computer science for simulation purposes associated with computer-aided design, response analyses, and data acquisition. Basic understanding of materials behavior

and structural performance is enhanced by laboratory courses involving static and dynamic stress failure tests of structural models, and response of structural systems. Within this area, students can specialize in (a) civil structures, (b) aerospace structures, (c) renewal of structures, or (d) earthquake engineering.

The **engineering sciences** program follows the overall Structural Engineering program except that the number of required design courses are reduced. In addition to core courses in dynamics, vibrations, structures, fluid mechanics, thermodynamics, heat transfer, and laboratory experimentation, a large number of technical electives are scheduled. This aspect of the curriculum allows flexibility by permitting specialization and in-depth study in one area of the engineering sciences or through a sequence of courses on various emerging technologies. Students must consult their advisers to develop a sound course of study to fulfill the technical elective requirements of this program.

Major Requirements

Specific course requirements for the major are outlined in a table herein. In addition to the required technical courses specifically indicated, a suggested scheduling of humanities and social science courses (HSS) are distributed in the curricula for students to use to meet college general-education requirements. To graduate, students must maintain an overall GPA of at least 2.0, and the department requires at least a C– grade in each course required for the major.

Deviations from the program of study must be approved by the Undergraduate Affairs Committee prior to taking alternative courses. In cases where a student needs to take a course outside UCSD, prior departmental approval is essential. In addition, technical elective (TE) course selections must have departmental approval prior to taking the courses. In the accredited program, TE courses are restricted to meet ABET standards. Courses such as SE 195, SE 197 and SE 198 are not allowed as technical electives in meeting the upper-division major requirements. SE 199 can be used as a technical elective only under restrictive conditions. Policies regarding these conditions may be obtained from the department's Student Affairs Office. Graduate level courses may be petitioned for technical elective credit.

Students with different academic preparations may vary the scheduling of lower-division courses such as math, physics and chemistry, but should consult the department prior to doing so. Deviations in scheduling lower-division Structural Engineering courses are discouraged due to scheduling constraints. A tentative schedule of course offerings is available from the department each spring quarter for the following academic year.

General-Education/College Requirement

For graduation, each student must satisfy general-education course requirements determined by the student's college, as well as the major requirements determined by the department. The six colleges at UCSD require widely different general-education courses, and the number of such courses differs from one college to another. Each student should choose his or her college carefully, considering the special nature of the college and the breadth of general education.

The Structural Engineering program allows for twelve humanities and social science (HSS) courses so that students can fulfill their college requirements. In the ABET accredited programs, students must develop a program that includes a total of at least twenty-four units in the arts, humanities, and social sciences, not including subjects such as accounting, industrial management, finance, or personnel administration. It should be noted, however, that some colleges may require more than twelve HSS courses indicated in the curriculum tables. Accordingly, students in these colleges may take longer to graduate than the indicated four-year schedule. Students must consult with their college to determine which HSS courses to take.

Professional Licensing

All students are encouraged to take the Engineering-in-Training (EIT) examination as the first step in becoming licensed as a professional engineer (PE). Students graduating from an accredited program can take the PE examination after EIT certification and two years of work experience; students graduating from a nonaccredited program can take the PE examination after EIT certification and four years of work experience.

For further information please contact the Student Affairs Office or your local Board of Registration for Professional Engineers and Land Surveyors.

STRUCTURAL ENGINEERING
(ABET Accredited Program)

Mission Statement

To provide a comprehensive education and training to engineers using a holistic approach to structural systems engineering by emphasizing and building on the commonality of engineering structures at the levels of materials, mechanics, analysis, and design.

GOALS

1. To provide our students with a strong technical education that will prepare students receiving Bachelor's degrees for professional careers in industry, or for continued graduate education in their area of specialization.
2. To provide our students with cross-disciplinary technical education to adequately prepare them for a rapidly changing technological world based on the commonality of knowledge across structural engineering disciplines thereby ensuring that they are able to continuously meet professional objectives throughout their careers.
3. To provide our students with a firm foundation for professional advancement not just through technical expertise, but also through communication skills, team and group activities, and ethical/professional responsibility as designers and engineers.

OBJECTIVES

- To provide a sound basis in the general sciences and mathematics that underlie the cross-disciplinary field of structural engineering.
- To provide a thorough training in the design principles and structural action as related to components and systems over a broad range of application areas.
- To provide a thorough training in the methods of analysis, including problem formulation and the use of current mathematical and computational tools.
- To provide an understanding of structural action at the component and systems level through design, analysis, and experimentation.
- To provide through structure and flexibility in the curriculum the opportunity for students to have both specialization (through focus sequences) and breadth (through technical electives) in the area of structural engineering.

- To instill in students the ability of critical and innovative thinking, and ability to formulate solutions based on sound principles of structural mechanics and materials.
- To teach students techniques of experimentation and data analysis, including the use of statistics and reliability methods required for structural applications.
- To teach the fundamentals of the design process initiating in conceptual design and culminating in final design including the use of appropriate codes of practice.
- To prepare students in the skills needs for successful professional practice as related to team participation, and effective verbal and written communication.
- To instill in our students an understanding and acceptance of their professional and ethical responsibilities.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Math. 20A	Math. 20B	Math. 20C
SE 1	MAE 9	SE 2
Chem. 6A	Phys. 2A	Phys. 2B/2BL
HSS[1]	HSS	HSS
SOPHOMORE YEAR		
Math. 20D	Math. 20F	Math. 20E
Phys. 2C/2CL	SE 102	SE 103
SE 101A	SE 101B	SE 110A
HSS	HSS	HSS
JUNIOR YEAR		
SE 121	SE 120	MAE 170
SE 125	MAE 101A	TE[2]
SE 110B	SE 130A	SE 130B
HSS	HSS	HSS
SENIOR YEAR		
SE 101C	SE 131	SE 140
TE	TE	FS
FS[3]	FS	FS
HSS	HSS	HSS

[1] In fulfilling the humanities and social science requirements (HSS), students must take a total of at least twenty-four units in the arts, humanities, and social sciences, not including subjects such as accounting, industrial management, finance, or personnel administration. Twelve HSS courses are listed here; individual college requirements may be higher.

[2] Technical elective (TE) course must be an upper-division or graduate course in the engineering sciences, natural sciences or mathematics, selected with prior approval of the department to meet ABET standards.

[3] Students must take one full focus sequence (FS) in either (a) Civil Structures (SE 150, SE 151A, SE 151B, SE 181), or (b) Aerospace Structures (SE 160A, SE 160B, SE 142, SE 163), or (c) Renewal of Structures (SE 142, SE 150, SE 151A, SE 163, SE 165), or (d) Earthquake Engineering (SE 180, SE 181, SE 182, SE 152). Students should note that not all focus sequence classes will be offered every year.

ENGINEERING SCIENCES
(Non-Accredited Program)

FALL	WINTER	SPRING
FRESHMAN YEAR		
Math. 20A	Math. 20B	Math. 20C
SE 1	MAE 9	SE 2
Chem. 6A	Phys. 2A	Phys. 2B/2BL
HSS[1]	HSS	HSS
SOPHOMORE YEAR		
Math. 20D	Math. 20F	Math. 20E
Phys. 2C/2CL	SE 102	SE 103
SE 101A	SE 101B	SE 110A
HSS	HSS	HSS
JUNIOR YEAR		
SE 121	SE 120	MAE 170
SE 125	MAE 101A	TE[2]
SE 110B	SE 130A	SE 130B
HSS	HSS	HSS
SENIOR YEAR		
SE 101C	SE 131	SE 140
TE	TE	TE
TE	TE	TE
HSS	HSS	HSS

[1] In fulfilling the humanities and social science requirements (HSS), students must take a total of at least twenty-four units in the arts, humanities, and social sciences, not including subjects such as accounting, industrial management, finance, or personnel administration. Ten HSS courses are listed here; individual college requirements may
be higher.

[2] Technical elective (TE) course must be an upper-division or graduate course in the engineering sciences, natural sciences or mathematics, selected with prior approval of the department to meet ABET standards.

Policies and Procedures for Structural Engineering Undergraduate Students

Admission to the Major

Admission to the department as a Structural Engineering major, or to fulfill a major in another department which requires Structural Engineering courses, is in accordance with the general requirements established by the School of Engineering. The admission requirements and procedures are described in detail in the section on "Admiss-ion to the School of Engineering" in this catalog. All students are expected to complete lower- and upper-division courses, as suggested in the curriculum tables, in a timely fashion in the sequences outlined.

Transfer Students

Requirements for admission as a Structural Engineering major, or into Structural Engineering courses, are the same for transfer students as they are for continuing students (see section on "Admission to the School of Engineering" in this general catalog). Accordingly, when planning their program, transfer students should be mindful of lower-division prerequisite course requirements, as well as for meeting collegiate requirements.

Students who have taken equivalent courses elsewhere may request to have transfer credits apply toward the department's major requirements. This is accomplished by submitting a petition for transfer credits together with a transcript and catalog course description from the institution where the course(s) were taken. These documents are reviewed for approval by the Structural Engineering Undergraduate Affairs Committee.

Effective **fall 2004**, it is **strongly recommended** that transfer students complete the following preparation for engineering majors*:

- Calculus I—for Science and Engineering (Math. 20A)
- Calculus II—for Science and Engineering (Math. 20B)
- Calculus and Analytic Geometry (Math. 20C)
- Differential Equations (Math. 20D)
- Linear Algebra (Math. 20F)
- Complete calculus-based physics series with lab experience (Physics 2A-B-C)
- Chemistry 6A (except Computer Science and Computer Engineering majors)
- Highest level of introductory computer programming language course offerings at the community college**

*Effective **fall 2006**, these courses will be **required** preparation for all engineering transfer students.
**Refer to the *UCSD General Catalog* to select major prerequisite requirement for computer language courses.

No transfer credit will be given for courses similar to SE 1 and SE 2. SE 1 and SE 2 must be taken by all students majoring in Structural Engineering.

Transfer petitions are available from the Structural Engineering Student Affairs Office.

Academic Advising

Upon arrival, students must make an appointment with the undergraduate adviser in the Structural Engineering Student Affairs Office to plan a program of study. The program plan may be revised in subsequent years, but revisions involving curricular requirements require approval by the undergraduate adviser or the Undergrad-uate Affairs Committee. Because some courses and/or curricular changes may be made every year, it is imperative that students consult with the department's undergraduate adviser and their assigned faculty adviser on an annual basis.

Many Structural Engineering courses are offered only once a year and therefore should be taken in the recommended sequence. If courses are taken out of sequence, it may not always be possible to enroll in subsequent courses as desired or needed. If this occurs, students should seek immediate department advice. When a student deviates from the sequence of courses specified for the curriculum in this catalog, it may be impossible to complete the Structural Engineering major within the normal four-year period. Structural Engineering advisers will be monitoring the progress of students in order for them to remain on track.

In addition to the advise available through the Structural Engineering Student Affairs Office, programmatic or technical advice may be obtained from Structural Engineering faculty members. A specific Structural Engineering faculty adviser is assigned to each Structural Engineering student. All Structural Engineering students are required to meet with their faculty adviser at least once a year, preferably before the beginning of fall quarter.

Program Alterations/Exceptions to Requirements

Variations from, or exceptions to, any program or course requirements are possible only if a petition is approved by the Structural Engineering Undergraduate Affairs Committee before the courses in question are taken. Petition forms may be obtained from the Structural Engineering Student Affairs Office and must be processed through this office.

Independent Study

Structural Engineering students may take SE 199, Independent Study for Undergraduates, under the guidance of a Structural Engineering faculty member. Normally, this course is taken as an elective on a P/NP basis. Under very restrictive conditions, however, it may be used to satisfy upper-division technical elective course requirements for the major. Students interested in this alternative must identify a faculty member with whom they wish to work and propose a two-quarter research or study topic. After obtaining the faculty member's concurrence on the topic and scope of the study, the student must submit a Special Studies Course form (each quarter) and the "SE 199 as Technical Elective Contract" form to the Structural Engineering Undergraduate Affairs Committee. These forms must be completed, approved, and processed **prior** to the beginning of the quarter in which the course is to be taken. This should not be done during the add/drop period. Detailed policy in this regard and the requisite forms may be obtained from the Student Affairs Office.

Teaching

Students interested in participating in the instructional activities of the department may take SE 195, Undergraduate Teaching. Policy in this regard and the appropriate forms may be obtained from the Structural Engineering Student Affairs Office.

Bachelor's/Master's Program

The department offers a bachelor's/master's degree program to enable students to complete both the B.S. and M.S. degrees in an accelerated timeframe. Undergraduate students in the Department of Structural Engineering who have at least 148 quarter units with a cumulative 3.5 M.W. GPA are eligible to apply. Admission to the bachelor's/master's degree program is not automatic. Student applications are reviewed and the final decision is made by the Department of Structural Engineering. Acceptance into this program is an honor which carries with it practical benefits—the graduate application process is simplified (no GREs required) and advanced students are given access to graduate level courses. Upon acceptance as an undergraduate into the program, a faculty member will be assigned who will serve as the student's adviser. Interested students should contact the Structural Engineering Student Affairs Office. Students must fulfill all requirements for the B.S. degree prior to being formally admitted to graduate status.

The Graduate Program

The Department of Structural Engineering offers instruction leading to the degrees of Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in Structural Engineering (SE). The graduate program is aimed at training a select number of highly skilled professionals in structural engineering with the academic and engineering credentials to assume leadership roles in industry and academia.

The M.S. degree program is intended to provide students with additional fundamental knowledge as well as specialized advanced knowledge in selected structural engineering aspects over and above the undergraduate degree course work.

The Doctor of Philosophy (Ph.D.) degree program is intended to prepare students for careers in teaching, research, and/or in their chosen professional specialties. The Ph.D. program requires a departmental comprehensive examination, a Ph.D. candidacy examination, a Ph.D. dissertation based on new and unique research, and a dissertation defense.

Both degrees offer opportunities for training in one or more of the four primary research thrusts within the SE department which are in (1) Earthquake Engineering, (2) Advanced Composites and Aerospace Structural Systems, (3) Renewal Engineering, and (4) Damage Prognosis and Validated Simulations.

Admission to the UCSD graduate division requires at least a B.S. degree in engineering, physical sciences, or mathematics with an overall upper-division GPA of 3.0. Applicants must provide three letters of recommendation and recent GRE general test scores. A minimum TOEFL score of 550 (213 computer-based) is required from international applicants whose native language is not English. Based on the candidate's background, qualifications, and career objectives, admission to the program is in one of two categories: M.S. or Ph.D.

Applicants seeking enrollment in SE courses via UC Extension's concurrent registration program are advised to refer to the ***Graduate Studies Transferring Credit*** section of the *UCSD General Catalog* for clarification.

Master's Degree Program

The M.S. degree program is intended to provide the student with additional fundamental knowledge as well as specialized advanced knowledge in selected structural engineering aspects over and above the undergraduate degree course work. Two plans, the M.S. Thesis Plan and the M.S. Comprehensive Examination Plan, are offered. The M.S. Thesis Plan is designed for those students with an interest in research prior to entering the structural engineering profession or prior to entering a doctoral degree program. The M.S. Thesis Plan involves course work and research culminating with the preparation and defense of a master's thesis. The M.S. Comprehensive Examination Plan involves course work and culminates with a public oral presentation related to the courses the student has taken. The topic is selected by the student's adviser. This presentation is evaluated by a committee of three faculty and must take place in the final quarter of courses.

M.S. students must complete forty-eight units of credit for graduation. For the M.S. Comprehensive Examination Plan all forty-eight units of credit must consist of regular courses (twelve courses). For the M.S. Thesis Plan, thirty-six units (nine courses) from regular courses are required, in addition to twelve units of graduate research for the master's thesis. For both M.S. plans, students are required to complete a minimum of two sequences from the following focus areas:

1. Structural Analysis
2. Structural Design
3. Earthquake Engineering
4. Advanced Composites
5. Solid Mechanics
6. Advanced Structural Behavior

A sequence is composed of three regular courses from the same focus area. The courses comprising the focus sequences are listed in the table in this section. To meet the specific needs of some students, other focus areas may be developed by a student in consultation with his or her adviser, but these must be approved by the SE Graduate Affairs Committee. To allow for greater flexibility in the program, the remaining credits required from courses may be earned by completing additional focus sequences, parts of focus sequences, or other appropriate courses. Students may elect to take other appropriate technical electives (with the approval of their adviser and the SE Graduate Affairs Committee). Up to twelve units of upper-division undergraduate (100-level) courses will be allowed in the M.S. program. Units obtained in SE 290, 291, and 298 may not be applied towards course work requirements. No more than four units of SE 296 may be applied toward course work requirements and only with **prior** approval of the SE Graduate Affairs Committee.

The department also offers two seminar courses each quarter dealing with current research topics in Earthquake Engineering (SE 290) and Advanced Composites (SE 291). The SE distinguished seminar series is administered within these two seminar courses. The SE distinguished seminar series features prominent speakers from academic, industry, and national laboratories. All master's students are required to take one of these two seminar courses each quarter they are registered.

Focus Sequences

FOCUS SEQUENCE	COURSES
Structural Analysis	Advanced Structural Analysis Structural Stability Structural Dynamics Random Vibrations
Structural Design	Advanced RC/PC Design Advanced Structural Steel Design Bridge Design
Earthquake Engineering	Structural Dynamics Earthquake Engineering Geotechnical Earthquake Engineering Advanced Seismic Design of Structures
Advanced Composites	Design of Composite Structures Processing Science of Composites Experimental Mechanics and NDE Mechanics of Laminated Composite Structures Textile Composite Structures
Solid Mechanics	Solid Mechanics for Structural and Aerospace Engineering Theory of Elasticity Theory of Plasticity and Viscoelasticity Experimental Mechanics and NDE
Advanced Structural Behavior	Nonlinear Mechanical Vibrations Structural Reliability and Risk Analysis Random Vibrations Experimental Mechanics and Nondestructive Evaluation

The thesis defense is the final examination for students enrolled in the M.S. thesis plan and must be conducted after completion of all course work. Upon completion of the research project, the student writes a thesis that must be successfully defended in an oral examination and public presentation conducted by a committee composed of three faculty. A complete copy of the student's thesis must be submitted to each member of the M.S. thesis committee (comprised of a minimum of three faculty) at least two weeks before the defense.

Doctoral Degree Program

The Ph.D. program is intended to prepare students for a variety of careers in research, teaching and advanced professional practice in the broad sense of structural engineering, encompassing civil and aerospace structures, earthquake and geotechnical engineering, composites, and engineering mechanics. Depending on the student's background and ability, research is initiated as soon as possible. All students, in consultation with their advisers, develop course programs that will prepare them for the Departmental Comprehensive Examination and for their dissertation research. However, these programs of study and research must be planned to meet the time limits established to advance to candidacy and to complete the requirements for the degree. Doctoral students who have passed the Departmental Comprehensive Examination may take any course for an S/U grade, with the exception of any course that the student's Departmental Comprehensive or Ph.D. Candidacy Examination Committee stipulates must be taken in order to remove a deficiency. It is strongly recommended that all Structural Engineering graduate students take a minimum of two courses (other than research) per academic year after passing the Departmental Comprehensive Examination.

The department also offers two seminar courses each quarter dealing with current research topics in Earthquake Engineering (SE 290) and in Advanced Composite Materials (SE 291). All Ph.D. students are required to take one of these two seminar courses each quarter they are registered.

Doctoral Examinations: A Structural Engineering Ph.D. student is required to pass three examinations. The first is a **Departmental Comprehensive Examination** which should be taken within three to six quarters of full-time

graduate study and requires a 3.5 GPA. This examination is intended to determine the student's ability to successfully pursue a research project at a level appropriate for the doctoral degree. It is administered by at least four faculty, three of whom must be in Structural Engineering. The student is responsible for material pertaining to four focus areas. One focus area can be satisfied by course work, provided that all courses in that area have been taken at UCSD, the grade in each course is B or better, and the overall GPA in that area is at least 3.5. In order to insure appropriate breadth, the focus areas should consist of the following: (a) two focus areas within Structural Engineering which are closely related to the student's research interests, (b) one focus area within Structural Engineering that is not directly related to the student's area of research, and (c) one minor focus area outside the Department of Structural Engineering. Minor areas too closely related to the major areas will not be approved by the SE Graduate Affairs Committee. The Solid Mechanics Focus Sequence, which is jointly taught by Structural Engineering and the Department of Mechanical and Aerospace Engineering, cannot be used to satisfy the outside Structural Engineering requirement. Students intending to specialize in the emerging areas of structural health monitoring, damage prognosis, and validated simulations are advised to take courses in the focus areas of Advanced Structural Behavior and elective courses MAE 283, MAE 261, ECE 251AN, ECE 254, and CSE 291 which can be used to satisfy the outside Structural Engineering requirement.

Since the examination areas must be approved by the SE Graduate Affairs Committee, students are advised to seek such approval well before their expected examination date, preferably while planning their graduate studies. Although students are not required to take particular courses in preparation for the departmental comprehensive examination, the scope of the examination in each area is associated with a set of three graduate courses, generally focus sequences offered or approved by the department. A candidate can develop a sense of the level of knowledge expected to be demonstrated during the examination by studying the appropriate syllabi and/or discussing the course content with faculty experienced in teaching the courses involved. The Departmental Comprehensive Examination may be a written or an oral examination, at the discretion of the committee.

Teaching experience is required of all Structural Engineering Ph.D. students prior to taking the Ph.D. Candidacy Examination. Teaching experience is defined as lecturing one hour per week in either a problem-solving section or laboratory session, for one quarter in an undergraduate course designated by the department. The requirement can be fulfilled by service as a teaching assistant or taken as a course for academic credit. Students must contact the Student Affairs Office to plan for completion of this requirement.

The **Ph.D. Candidacy Examination** is the second examination required of Structural Engineering doctoral students. In preparation for the Ph.D. Candidacy Examination, students must have completed the Departmental Comprehensive Examination and the Departmental Teaching Experience requirement, obtained a faculty research adviser, have identified a topic for their dissertation research, and have made initial progress in that research. At the time of application for advancement to candidacy, a doctoral committee responsible for the remainder of the student's graduate program is appointed by the Graduate Council. In accordance with Academic Senate Regulations 715(D): "A doctoral committee of five or more members shall be appointed by the dean of Graduate Studies under the authority of the Graduate Council. The committee members shall be chosen from at least two departments, and at least two members shall represent academic specialties that differ from the student's chosen specialty. In all cases, each committee must include one tenured UCSD faculty member from outside the student's major department." The committee conducts the Ph.D. Candidacy Examination, during which students must demonstrate the ability to engage in dissertation research. This involves the presentation of a plan for the dissertation research project. A short written document describing the research plan must be submitted to each member of the committee at least two weeks before the Ph.D. Candidacy Examination. The committee may ask questions directly or indirectly related to the research project and general questions that it determines to be relevant. Upon successful completion of this examination, students are advanced to candidacy and are awarded the Candidate in Philosophy degree. The Ph.D. Candidacy Examination is an oral examination.

The Dissertation Defense is the final Ph.D. examination. Upon completion of the dissertation research project, the student writes a dissertation that must then be successfully defended in an oral examination and public presentation conducted by the doctoral committee. A complete copy of the student's dissertation must be submitted to each member of the doctoral committee at least four weeks before the defense. While the copy of the dissertation handed to the committee is expected to be complete and in final form, it should be noted that students are expected to make changes in the text per direction of the committee as a result of the defense. This examination cannot be conducted earlier than three quarters after the date of advancement to doctoral candidacy. Acceptance of the dissertation by the Office of Graduate Studies and Research and the university librarian represents the final step in completion of all requirements for the Ph.D.

Ph.D. Time Limit Policy. Pre-candidacy status is limited to four years. Doctoral students are eligible for university support for six years. The defense and submission of the doctoral dissertation must be within seven years.

Evaluations. In the spring of each year, the faculty evaluate each doctoral student's overall performance in course work, research, and prospects for financial support for future years. A written assessment is given to the student after the evaluation. If a student's work is found to be inadequate, the faculty may determine that the student cannot continue in the graduate program.

COURSES

All students enrolled in Structural Engineering courses or admitted into a Structural Engineering program are expected to meet prerequisite and performance standards, i.e., students may not enroll in any SE courses or courses in another department which are required for the major prior to having satisfied prerequisite courses with a C– or better. (The department does not consider D or F grades as adequate preparation for subsequent material.) Additional details are given under the various program outlines, course descriptions, and admission procedures for the School of Engineering in this catalog. Furthermore, the majority of SE courses have enrollment restrictions which give priority to, or are open only to, declared pre-engineering students and/or to students who have been admitted to an engineering major. Where these restrictions apply, the registrar will not enroll

other students except by department stamp on class enrollment cards. The department expects that students will adhere to these policies on their own volition and enroll in courses accordingly. Students are advised that they may be dropped at any time from course rosters if prerequisites and/or performance standards have not been met.

While some lower-division courses may be offered more than once each year, most SE upper-division courses are taught only once per year, and courses are scheduled to be consistent with the curricula as shown in the tables. When possible, SE does offer selected large enrollment courses more than once each year. A tentative schedule of course offerings is available from the department each spring for the following academic year.

LOWER-DIVISION

SE 1. Introduction to Structures and Design (4)
Introduction to structural components, systems from aerospace, civil, mechanical, marine and offshore areas. Structural action, the design process. History of structural engineering. Role and responsibility of structural engineers in society. Engineering economics, costs-benefits analysis. Implications on safety. Professional ethics. *Prerequisite: priority enrollment given to structural engineering majors.*

SE 2. Structural Materials (4)
Structure of engineering materials (metals, ceramics, concrete, composites) tailoring to produce desired properties and response in structural components and systems. Mechanical tests, elasticity, plastic deformation, fracture, toughness, creep and fatigue. Selection based on performance requirements/application. Laboratory demonstrations and tests. *Prerequisites: Chem. 6A, Phys. 2A. Priority enrollment given to structural engineering majors and mechanical and aerospace engineering majors.*

SE 87. Freshman Seminar (1)
The freshman seminar program is designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small seminar setting. Freshman seminars are offered in all campus departments and undergraduate colleges, and topics vary from quarter to quarter. *Prerequisite: open to freshmen only.*

UPPER-DIVISION

SE 101A. Mechanics I: Statics (4)
Principles of statics using vectors. Two- and three-dimensional equilibrium of statically determinate structures under discrete and distributed loading including hydrostatics; internal forces and concept of stress; free body diagrams; moment, product of inertia; analysis of trusses and beams. *Prerequisites: grades of C– or better in Math. 20C and Phys. 2A.*

SE 101B. Mechanics II: Dynamics (4)
Kinematics and kinetics of particles in two- and three-dimensional motion using vector representation. Orbital mechanics. Work, energy, and power. Conservative forces, conservation principles. Momentum, impulsive motion, and impact. Rigid body kinetics and kinematics; Coriolis acceleration, Eulerian angles. Undamped vibrating systems. *Prerequisites: grades of C– or better in Math. 20D, and SE 101A, or MAE 130A.*

SE 101C. Structural Mechanics III: Structural Dynamics (4)
Free and forced vibrations of damped 1-DOF systems; vibrations isolation, impact and packaging problems. Analysis of discrete MDOF systems using matrix representation; normal mode of frequencies and modal matrix formulation. Lagrange's equations. Modal superposition for analysis of continuous vibrating systems. *Prerequisites: grade of C- or better in SE 101B (or MAE 130B) and SE 130B; SE major.*

SE 102. Numerical, Computational, and Graphical Tools (4)
Introduction to engineering graphics and computer-aided design (CAD). Introduction to numerical computer algorithms and symbolic computation. Introduction to the development of methods for assessing the accuracy of numerical methods. *Prerequisites: grade of C- or better in MAE 9 and SE 101A or MAE 130A; SE major.*

SE 103. Conceptual Structural Design (4)
Introduction to design principles and structural action. Development of design theories, approaches and methodology. Concepts of load and resistance factors, factors of safety, limit and ultimate states, design allowables. Simple design examples from aerospace, civil, marine, offshore and mechanical structural systems. *Prerequisites: grade of C– or better in SE 2, SE 101A.* Priority enrollment given to structural engineering majors.

SE 110A. Solid Mechanics I (4)
Mechanics of deformable bodies under axial, torsional, shearing, and bending loads. Elastic and plastic uniaxial material response as well as 3-D Hooke's law. Mohr's circle for stress and strain. Problems of design for rods, shafts, beams, columns, pressure vessels, and thin walled members. *Prerequisites: grades of C– or better in Math. 20D, 20F, SE 101A.* Priority enrollment given to structural engineering majors.

SE 110B. Solid Mechanics II (4)
Advanced concepts in the mechanics of deformable bodies. Unsymmetrical bending of symmetrical and unsymmetrical sections. Bending of curved beams. Shear center and torsional analysis of open and closed sections. Stability analysis of columns, lateral buckling. Application of the theory of elasticity in rectangular coordinates. *Prerequisite: grade of C– or better in SE 110A.* Priority enrollment given to structural engineering majors.

SE 120. Engineering Graphics & Computer Aided Structural Design (4)
Engineering graphics, solid modeling, CAD applications including 2-D and 3-D transformations, 3-D viewing, wire frame and solid models, Hidden surface elimination. *Prerequisite: grade of C– or better in MAE 9.* Priority enrollment given to structural engineering majors.

SE 121. Numerical Methods in Engineering (4)
Advanced numerical methods for applications for engineering problems. Solution of systems of linear and nonlinear equations, function interpolation and curve fitting, function approximation, computation of integrals, numerical differentiation, and solution of systems of ordinary differential equations. *Prerequisites: grade of C- or better in SE 102, and Math. 20F; SE major.*

SE 125. Statistics, Probability and Reliability (4)
Probability theory. Statistics, data analysis and inferential statistics, distributions, confidence intervals. Introduction to structural reliability and random phenomena. Applications to components and systems. *Priority enrollment given to structural engineering majors.*

SE 130A-B. Structural Analysis (4)
Classical methods of analysis for statically indeterminate structures. Development of computer codes for the analysis of civil, mechanical, and aerospace structures from the matrix formulation of the classical structural theory, through the direct stiffness formulation, to production-type structural analysis programs. *Prerequisites: grades of C– or better in SE 110 A, SE 121, and SE 130A for SE 130B.* Priority enrollment given to structural engineering majors.

SE 131. Finite Element Analysis (4)
Development of stiffness and mass matrices based upon virtual work and variational principles. Application to static and dynamic problems in structural and solid mechanics. The use of general purpose finite element structural analysis codes. *Prerequisites: grade of C- or better in SE 103, SE 130B, MAE 170, and senior standing in the major.*

SE 140. Structures and Materials Laboratory (4)
Introduction to instrumentation and testing techniques. Discussion of standard tension and compression tests. Similitude relationships for structural models. Term project in model structure including complete engineering report on theory, design and results of the term project. *Prerequisites: grade of C– or better in SE 103, SE 130B, MAE 170, and senior standing in the major.*

SE 142 . Design of Composite Structures (4)
Design and analysis of lightweight structures composed of laminated composite materials. Stiffness, strength, failure mechanisms, micromechanics, and hygrothermal behavior. Fabrication and experimental testing. Design projects that involve computer implementation. *Prerequisites: grade of C– or better in SE 110A-B; priority given to engineering majors.*

SE 144 . Aerospace Structural Analysis (4)
Aspects of structural analysis pertinent to the design of flight vehicles; aerodynamic/inertial loadings, aerospace laminated materials, elements of plate theory, aeroelastic divergence, introduction of matrix methods for structural dynamics and buckling. *Prerequisites: grades of C– or better in SE 101C, SE 110A-B.* Priority enrollment given to structural engineering majors and mechanical and aerospace engineering majors.

SE 150. Design of Steel Structures (4)
Design concepts and loadings for structural systems. Working stress and ultimate strength design theories. Properties of structural steel. Elastic design of tension members, beams, and columns. Design of bolted and welded concentric and eccentric connections. Design of composite floors. Introduction to plastic design. *Prerequisites: grade of C– or better in SE 103, and SE 130A.* Priority enrollment given to structural engineering majors.

SE 151A-B. Design of Structural Concrete (4-4)
Concrete and reinforcement properties. Service and ultimate limit state analysis and design. Design and detailing of structural components. Concept of prestressing. Design and application of prestressed structures and components. *Prerequisites: grade of C- or better*

in SE 103, SE 130A and SE 130B. SE 151A for SE 151B; SE major.

SE 152. Seismic Design of Structures (4)
Seismic design philosophy. Ductility concepts. Lateral force resisting systems. Mechanisms of nonlinear deformation. Methods of analysis. Detailing of structural steel and reinforced concrete elements. Lessons learned from past earthquakes. Multistory building design project. *Prerequisites: grade of C- or better in SE 103, SE 130A, SE 130B, SE 150 and SE 151A; concurrent enrollment in SE 151B; SE major.*

SE 154. Design of Timber Structures (4)
Properties of wood and lumber grades. Beam design. Design of axially loaded members. Design of beam-column. Properties of plywood and structural-use panels. Design of horizontal diaphragms. Design of shear walls. Design of nailed and bolted connections. *Prerequisites: grade of C- or better in SE 103 and SE 130A; SE major.*

SE 160A. Aerospace Structural Design (4)
Aircraft and spacecraft flight load definition and operational envelopes, metallic and composite material selection and comparison, applied elasticity, failure theories, stiffened shear panels, thin-wall open and closed-cell torsion pressure vessels, unsymmetical beam bending, shear center, and bending of plates. *Prerequisites: grade of C- or better in SE 2, SE 101B (or MAE 130B), and SE 110A (or MAE 131A); priority given to engineering majors.*

SE 160B. Aerospace Structural Design (4)
Work-energy principles, statically indeterminate structures, matrix methods, application of finite element method to aerospace structures, sandwich composite structures, structural dynamics of space structures, structural stability of beams, and shells, tension field beams, wing divergence and control reversal, flutter, fasteners, and structural joints. *Prerequisites: grade of C- or better in SE 160A, and SE 101C or MAE 130C; priority given to engineering majors.*

SE 162. Composites – Materials and Manufacturing (4)
Introduction to fibers, resins, composite types, manufacturing methods, stiffness, strength, failure mechanisms, lamination theory, testing. *Prerequisites: grades of C– or better in SE 110A, SE 121, and Math 20F.* Priority enrollment given to structural engineering majors.

SE 163. Nondestructive Evaluation (4)
Damage detection, materials characterization. Introduction to nondestructive evaluation. Impedance-based methods, ultrasonics, acoustic, thermography, shearography, liquid penetrant, proof testing, stress coatings, vibrational techniques. *Prerequisites: grade of C- or better in SE 110A and SE 110B or consent of instructor; SE major.*

SE 165. Introduction to Structural Health Monitoring (4)
A modern paradigm of structural health monitoring as it applies to structural and mechanical systems is presented. Concepts in data acquisition, feature extraction, and statistical modeling will be introduced in an integrated context. Laboratory exercises and demonstrations. *Prerequisites: grade of C– or better in SE 101C and SE 110B. Strong recommended knowledge of MATLAB, SE major.*

SE 170. Civil Structures Rehabilitation (4)
Identification of structural distress, lessons from past history, materials and structural concepts related to rehabilitation, seismic retrofit. Strengthening of beams, slabs and walls, design detailing, safety factors, fabrication/installation methods. *Prerequisites: grade of C– or better in SE 103, SE 110A, SE 130A-B, and SE 151.* Priority enrollment given to structural engineering majors.

SE 171. Aerospace Structures Repair (4)
Identification of structural distress, corrosion/stress corrosion cracking, fatigue cracking, damage tolerance, integrity and durability of built-up members, patching, health monitoring. *Prerequisites: grade of C– or better in SE 103 and SE 130A-B.* Priority enrollment given to structural engineering majors.

SE 180. Earthquake Engineering (4)
Elements of seismicity and seismology. Seismic hazards. Dynamic analysis of structures underground motion. Elastic and inelastic response spectra. Modal analysis, nonlinear time-history analysis. Earthquake resistant design. Seismic detailing. *Prerequisites: grade of C– or better in SE 110A, and SE 130A.* Priority enrollment given to structural engineering majors.

SE 181. Geotechnical Engineering (4)
General introduction to physical and engineering properties of soils. Soil classification and identification methods. Compaction and construction control. Total and effective stress. Permeability, seepage, and consolidation phenomena. Shear strength of sand and clay. *Prerequisites: grade of C- or better in SE 110A or MAE 131A; SE major.*

SE 182. Foundation Engineering (4)
Application of soil mechanics to the analysis, design, and construction of foundations for structures. Soil exploration, sampling, and in-situ testing techniques. Stress distribution and settlement of structures. Bearing capacities of shallow foundations. Axial and lateral capacity of deep foundations, earth pressures on retaining walls. *Prerequisites: grade of C- or better in SE 181; SE major.*

SE 195. Teaching (2-4)
Teaching and tutorial assistance in a SE course under supervision of instructor. Not more than four units may be used to satisfy graduation requirements. (P/NP grades only.) *Prerequisites: B average in major, upper-division standing and consent of department chair. Department stamp required.*

SE 197. Engineering Internship (1-4)
An enrichment program, available to a limited number of undergraduate students, which provides work experience with industry, government offices, etc., under the supervision of a faculty member and industrial supervisor. Coordination of the Engineering Internship is conducted through UCSD's Academic Internship Program. *Prerequisites: completion of ninety units with a 2.5 GPA and consent of department chair. Department stamp required.*

SE 198. Directed Study Group (4)
Directed group study, on a topic or in a field not included in the regular department curriculum, by special arrangement with a faculty member. (P/NP grades only.) *Prerequisite: consent of instructor or department stamp.*

SE 199. Independent Study (4)
Independent reading or research on a problem by special arrangement with a faculty member. (P/NP grades only.) *Prerequisite: consent of instructor or department stamp.*

GRADUATE

SE 201. Advanced Structural Analysis (4)
Applications of advanced analytical concepts to structural engineering problems. Effects of approximations in the descretization and the type of finite elements under consideration. An introduction is given to the nonlinear behavior of structural systems focusing on basic concepts and computational techniques. *Prerequisites: SE 130A-B or equivalent, or consent of instructor.*

SE 202. Structural Stability (4)
Static, dynamic, and energy-based techniques and predicting elastic stability. Linear and nonlinear analysis of classical and shear deformable beams and plates. Ritz, Galerkin, and finite element approaches for frames and reinforced shells. Nonconservative aerodynamic (divergence flutter) and follower forces. *Prerequisite: SE 110B or consent of instructor.*

SE 203. Structural Dynamics (4)
Response of the linear systems to harmonic, periodic and transient excitations. Duhamel's integral response spectra. Principles of dynamics, Hamilton's principle and Lagrange's equations. Linearization of the equations of motion. Free and forced vibrations. Matrix iteration, Jacobi, normal mode and frequency response method. *Prerequisites: MAE 231A-B or consent of instructor.*

SE 204. Advanced Structural Dynamics (4)
Free- and forced-vibration response of continuous systems including axial and torsional vibrations of bars and transverse vibrations of beams, membranes and plates. Differential and integral formulations of the eigenvalue problem. Perturbation and iteration methods. Introduction to structural control.

SE 206. Random Vibrations (4)
Introduction to probability theory and random processes. Dynamic analysis of linear and nonlinear structural systems subjected to stationary and nonstationary random excitations. Reliability Studies related to first excursion and fatigue failures. Applications in earthquake engineering, offshore engineering, wind engineering, and aerospace engineering. *Prerequisites: SE 203 or equivalent and basic knowledge of probability theory (e.g., SE 125).*

SE 207. Topics in Structural Engineering (4)
A course to be given at the discretion of the faculty in which topics of current interest in structural engineering will be presented.

SE 211. Advanced Reinforced and Prestressed Concrete Design (4)
Advanced topics in concrete design, including frame and shear wall structures, design of connections. reinforced and prestressed concrete system evaluation for seismic resistance including confinement and ductility requirements. Upper and lower bound theories for slab design. *Prerequisites: SE 151, or equivalent background in basic RC/PC design, or consent of instructor.*

SE 212. Advanced Structural Steel Design (4)
(Formerly AMES 245) Load and resistance factor design (LRFD) philosophy. Behavior and design of steel elements for global and local buckling. Bracing requirements for stability. Conventional and advanced analysis techniques for P-delta effects. Cyclic behavior. Ductility requirement for seismic design. Composite construction. *Prerequisites: SE 201 and SE 150, or equivalent course, or consent of instructor.*

SE 213. Bridge Design (4)
Design and analysis of bridge structures, construction methods, load conditions. Special problems in analysis—box girders, curved and skewed bridges, environmental and seismic loads. Bearings and expansion joints. Time- temperature-dependent superstructure deformations. Conceptual/preliminary bridge design project. *Prerequisites: SE 201, and fundamental courses in RC and PC design, or consent of instructor.*

SE 214. Masonry Structures (4)
Analysis and design of unreinforced and reinforced masonry structures using advanced analytical techniques and design philosophies. Material properties, stability, and buckling of unreinforced masonry. Flexural strength, shear strength, stiffness, and ductility of reinforced masonry elements. Design for seismic loads. *Prerequisites: SE 151, or equivalent basic reinforced concrete course, or consent of instructor.*

SE 221. Earthquake Engineering (4)
Introduction to plate tectonics and seismology. Rupture mechanism, measures of magnitude and intensity, earthquake occurrence and relation to geologic, tectonic processes. Probabilistic seismic hazard analysis. Strong earthquake ground motion; site effects on ground motion; structural response; soil-structure interaction; design criteria; code requirements.

SE 222. Geotechnical Earthquake Engineering (4)
Influence of soil conditions on ground motion characteristics; dynamic behavior of soils, computation of ground response using wave propagation analysis and finite element analysis; evaluation and mitigation of soil liquefaction; soil-structure interaction; lateral pressures on earth retaining structures; analysis of slope stability.

SE 223. Advanced Seismic Design of Structures (4)
Introduction to fundamental concepts in seismic design of structures. Ductility. Elastic and inelastic response. Time-history analysis. Response spectral analysis. Force- and displacement-based design. Capacity design principles. Learning from earthquake damage. Performance-based design concepts.

SE 225. Probabilistic Seismic Hazard Analysis (4)
Modern seismic hazard analysis including seismic source characterization, ground motion attenuation relations, near source effects, development of design spectra and time histories, seismic risk studies, and implementation of the PEER framing equation.

SE 234. Plates and Shells (4)
General mathematical formulation of the theory of thin elastic shells; linear membrane and bending theories; finite strain and rotation theories; shells of revolution; shallow shells; selected static and dynamic problems; survey of recent advances.

SE 241. Advanced Soil Mechanics (4)
Advanced treatment of topics in soil mechanics, including state of stress, pore pressure, consolidation and settlement analysis, shear strength of cohesionless and cohesive soils, mechanisms of ground improvement, and slope stability analysis. Concepts in course reinforced by laboratory experiments.

SE 242. Advanced Foundation Engineering (4)
Advanced treatment of topics in foundation engineering, including earth pressure theories, design of earth retaining structures, bearing capacity, ground improvement for foundation support, analysis and design of shallow and deep foundations, including drilled piers and driven piles.

SE 243. Soil-Structure Interaction (4)
Advanced treatment of soils interaction with structures, including shallow and deep foundations, bridge abutments, retaining walls, and buried structures subjected to static and dynamic loading. Elastic approximation. Linear and nonlinear Winkler models p-y and t-z curves.

SE 244. Numerical Methods in Geomechanics (4)
Application of the finite element method to static and dynamic analysis of geotechnical structures. One-, 2-, and 3-D seismic site response of earth structures and slopes. Pore-pressure generation and effects during cyclic loading. System identification using strong motion array data.

SE 245. Constitutive Modeling and Numerical Implementation (4)
Development and numerical implementation of procedures to model the nonlinear behavior of engineering materials, including soil and concrete. Inelastic hyperbolic and elasto-plastic modeling of hysteretic response to cyclic loading. Behavior of soil-structure systems under transient loading, such as seismic earthquake excitation, will be discussed.

SE 251. Processing Science of Composites (4)
Introduction to processing, fabrication methods; process models; materials-process-microstructure interaction; materials selection; form and quality control. Wet layup/sprayup, autoclave cure, SMC; injection molding, RTM; resin infusion; winding and fiber placement; pultrusion. Process induced defects, environmental considerations.

SE 252. Experimental Mechanics and NDE (4)
Theory of electrical resistance strain gages, full-field coherent optical methods including photoelasticity, moire' and speckle interferometry, ultrasonics, thermography and fiberoptic sensing. Applications to materials characterization, defect detection and health monitoring of structures with emphasis on fiber-reinforced composites. *Prerequisites: SE 101A, SE 110A, and MAE 131B, or consent of the instructor.*

SE 253. Mechanics of Laminated Composite Structures (4)
Macro- and micro-material modeling. Classical and shear deformable laminate beam and plate theories developed via energy principles. Ritz, Galerkin, and finite element-based solutions to static, vibration, and stability problems. Assignments include computer program development and use of existing commercial programs. *Prerequisites: SE 101C, SE 110B, and SE 162 or equivalent, or permission of the instructor.*

SE 255. Textile Composite Structures (4)
Introduction to textile structure and behavior, mechanics of yarns and fabrics as relevant to structural composites and geotechnical applications. Mechanics of textiles and fabric-based composites. Applications in fiber reinforced composites, coated textile structures, geotextiles.

SE 261. Aerospace Engineering Design (4)
Advanced topics in the design of weight-critical aerospace structures. Topics include: static, dynamic and environmental load definitions; metallics and polymeric composite material selection; semi-monocoque analysis techniques, and bolted/bonded connections. Design procedures for sizing the structural components of aircraft and spacecraft will be reviewed.

SE 262. Aerospace Structures Repair (4)
Design and analysis for repairing weight-critical aerospace structures. Identification of primary and secondary structural components, review of NASA/FAA approved repair techniques for metallic and composite structural components.

SE 271. Solid Mechanics for Structural and Aerospace Engineering (4)
Application of principles of solid mechanics to structural components and systems, description of stresses, strains, and deformation. Use of conservation equations and principle of minimum potential energy. Development of constitutive equations for metallic cementitious and polymeric materials. *Prerequisites: SE 110A, or consent of instructor.*

SE 272. Theory of Elasticity (4)
Development, formulation, and application of field equations of elasticity and variational principles for structural applications in civil and aerospace area. Use of plane stress and plane strain formulation, solution of typical boundary value problems. *Prerequisites: SE 271, or consent of instructor.*

SE 273. Theory of Plasticity and Viscoelasticity (4)
Mechanical models of viscoelastic, plastic, and viscoplastic behavior in simple shear or uniaxial stress. Constitutive relations for three-dimensional states of stress and strain. Application to selected technological problems for civil and aerospace structural applications. *Prerequisites: SE 272, or consent of instructor.*

SE 290. Seminar in Earthquake Engineering (2)
Weekly seminar and discussion by faculty, visitors, postdoctoral research fellows and graduate students concerning research topics in earthquake engineering and related subjects. May be repeated for credit. *Prerequisite: consent of instructor.* (S/U grades only.)

SE 291. Seminar in Advanced Composite Structures (2)
Weekly seminar and discussion by faculty, visitors, postdoctoral research fellows and graduate students concerning research topics in advanced composite structures and related subjects. May be repeated for credit. *Prerequisite: consent of instructor.* (S/U grades only.)

SE 296. Independent Study (4)
Prerequisite: consent of instructor.

SE 298. Directed Group Study (1-4)
Directed group study on a topic or in a field not included in regular department curriculum, by special arrangement with a faculty member. *Prerequisite: consent of instructor.*

SE 299. Graduate Research (1-12)
(S/U grades permitted.)

SE 501. Teaching Experience (2)
Teaching experience in an appropriate SE undergraduate course under direction of the faculty member in charge of the course. Lecturing one hour per week in either a problem-solving section or regular lecture. *Prerequisite: consent of instructor and the department.* (S/U grades permitted.)