Structural Engineering

PROFESSORS

R. J. Asaro, Ph.D.
D. J. Benson, Ph.D.
J. P. Conte, Ph.D.
A. W. Elgamal, Ph.D.
P. J. Fox, Ph.D.
G. A. Hegemier, Ph.D., *Chair*
J. B. Kosmatka, Ph.D.
F. Lanza di Scalea, Ph.D.
J. E. Luco, Ph.D.
J. Restrepo, Ph.D.
F. Seible, Ph.D., P.E., *Dean, Jacobs School of Engineering*
P. B. Shing, Ph.D., *Vice Chair*
C. M. Uang, Ph.D.

ASSOCIATE PROFESSORS

T. Hutchinson, Ph.D., P.E.
H. Kim, Ph.D.
P. Krysl, Ph.D.
F. Kuester, Ph.D.
Y. Qiao, Ph.D.
M. Todd, Ph.D., *Vice Chair*

ASSISTANT PROFESSORS

Y. Bazilevs, Ph.D.
Q. Zhu, Ph.D.

LECTURER WITH POTENTIAL FOR SECURITY OF EMPLOYMENT

Y. Van Den Einde, Ph.D.

AFFILIATED FACULTY

R. Englekirk, Ph.D., P.E., *Adjunct Professor*
C. Farrar, Ph.D., *Adjunct Professor*
M. Seracini, Ph.D., *Adjunct Professor*

PROFESSIONAL RESEARCH STAFF

I. Bartoli, Ph.D., *Assistant Project Scientist*
G. Benzoni, Ph.D., *Research Scientist*
S. Coccia, Ph.D., *Assistant Project Scientist*
B. Kad, Ph.D., *Research Scientist*
J. Lu, Ph.D., *Assistant Project Scientist*

STUDENT AFFAIRS: 240-1 Science and Engineering Research Facility (SERF), University Center
http://www.structures.ucsd.edu

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 is 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 advisors 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 UC San Diego, 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 your local Board of Registration for Professional Engineers and Land Surveyors or visit http://www.dca.ca.gov/pels.

STRUCTURAL ENGINEERING (ABET ACCREDITED PROGRAM)

Program Mission and Objectives

The B.S. Structural Engineering program is accredited by the ABET Inc. Engineering Accreditation Commission (Accreditation Board for Engineering and Technology). Accreditation is an assurance that the program meets established quality standards.

B.S. Structural Engineering Mission

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.

B.S. Structural Engineering Objectives

Program objectives represent graduates' performance three to five years after completing the B.S. program:

1. To provide our students receiving bachelor's degrees with a strong technical education that will prepare them for successful professional careers in industry, or for continued graduate education in their area of specialization
2. To provide our students with fundamental structural engineering principles that can be applied across multiple engineering applications (such as aerospace, civil, marine, and mechanical).
3. To provide our students with broad multidisciplinary skills necessary to accomplish professional objectives in a rapidly changing technological world.
4. To provide our students with the ethical standards, communication and collaboration skills essential for professional practice and career advancement.

B.S. Structural Engineering Outcomes

Program outcomes are the expected knowledge, skills, attitudes, and behaviors of students at the time of completing the B.S. program:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design and conduct experiments, as well as being able to analyze and interpret data
3. An ability to design a system, component, or process to meet desired needs
4. An ability to function in multidisciplinary teams
5. An ability to identify, formulate, and solve engineering problems
6. An understanding of professional and ethical responsibility
7. An ability to communicate effectively with written, oral, and visual means
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context
9. A recognition of the need for and an ability to engage in lifelong learning
10. A knowledge of contemporary issues
11. An ability to use modern engineering techniques, skills, and computing tools necessary for engineering practice

FALL	WINTER	SPRING
FRESHMAN YEAR		
Math. 20A	Math. 20B	Math. 20C
SE 1	HSS	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 110A	SE 102
SE 101A	SE 101B	SE 110B
HSS	SE 9[2]	SE 101C
JUNIOR YEAR		
SE 121	SE 130A	MAE 170
SE 103	SE 115	TE[3]
HSS	HSS	SE 130B
HSS	HSS	HSS
SENIOR YEAR		
SE 125	SE 131	SE 140
TE	SE 120	FS
FS[4]	FS	FS
HSS	HSS	TE

[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]Transfer students admitted to the university prior to fall 2010 who have completed MAE 9 are not required to take SE 9. Freshman students admitted to the university prior to fall 2007 who have completed MAE 9 are not required to take SE 9.

[3]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.

[4]Students must take one full-focus sequence (FS) in: (a) Civil Structures, (b) Aerospace Structures, (c) Renewal of Structures, or (d) Geotechnical Engineering. Students should note that not all focus sequence classes will be offered every year. Students admitted to the university prior to fall 2010 will be allowed to use the courses outlined in past focus sequences from the catalog year in which they entered the university.

Engineering Sciences (Nonaccredited Program)

FALL	WINTER	SPRING
FRESHMAN YEAR		
Math. 20A	Math. 20B	Math. 20C
SE 1	HSS	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 110A	SE 102
SE 101A	SE 101B	SE 110B
HSS	SE 9[2]	SE 101C
JUNIOR YEAR		
SE 121	SE 130A	MAE 170
SE 103	SE 115	TE[3]
HSS	HSS	SE 130B
HSS	HSS	HSS
SENIOR YEAR		
SE 125	SE 131	SE 140
TE	SE 120	TE
TE	TE	TE
HSS	HSS	TE

[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]Transfer students admitted to the university prior to fall 2010 who have completed MAE 9 are not required to take SE 9. Freshman students admitted to the university prior to fall 2007 who have completed MAE 9 are not required to take SE 9.

[3]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

Students who declare a Structural Engineering major will be directly admitted to the major. 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 a Structural Engineering major, or into Structural Engineering courses, are the same for transfer students as they are for continuing students. 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.

No transfer credit will be given for courses similar to SE 1, SE 2, SE 9. SE 1, SE 2, and SE 9 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 advisor 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 advisor or the Undergraduate 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 advisor and their assigned faculty advisor 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. Students should refer to the four-year plan and course prerequisite map on the department Web site at http://www.structures.ucsd.edu.

In addition to the advising 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 advisor is assigned to each Structural Engineering student. All Structural Engineering students are required to meet with their faculty advisor 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 restrictive conditions, however, it may be used to satisfy upper-division technical elective course requirements for the major. Students interested in taking an SE 199 course must identify a faculty member with whom they wish to work and propose a 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 to the Structural Engineering Undergraduate Affairs Committee. Students who are interested in having the course count as a technical elective requirement must take the course(s) for a total of four units and must also submit an Undergraduate Petition form. The 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.

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). In addition, an M.S. degree in structural health monitoring, prognosis, and validated simulations has been activated. 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 focus areas within the SE department: (1) Earthquake Engineering, (2) Advanced Composites and Aerospace Structural Systems, (3) Renewal Engineering, and (4) Structural Health Monitoring, Prognosis, and Validated Simulations.

Admission to the UC San Diego graduate program in Structural Engineering 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. International applicants whose native language is not English are required to demonstrate proficiency in English by taking the TOEFL test. The minimum TOEFL score required is 550 (paper-based), 213 (computer-based), and 80 (Internet-based text [iBt]). Based on the candidate's choice, 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 *UC San Diego General Catalog* for clarification.

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 GPA of 3.5 or higher 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 that 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 advisor. 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.

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 leading to the completion and defense of a master's thesis. The M.S. Comprehensive Examination Plan involves course work and requires the completion of a written comprehensive examination covering multiple courses that the student has taken. The M.S. Comprehensive examination will be comprehensive and cover two focus sequences and at least one additional technical elective that the student has taken. The examination must be completed no later than the end of the eighth week of the quarter the student intends to graduate.

Master students will be required to complete three core courses before they can graduate with their master's degree. The courses are SE 200 Applied Mathematics in Structural Engineering (or one of the following two similar courses: MAE294A and Math. 210A), SE 201 Advanced Structural Analysis, and SE 271 Solid Mechanics for Structural and Aerospace Engineering.

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. Computational Mechanics
4. Earthquake Engineering
5. Geotechnical Engineering
6. Advanced Composites
7. Solid Mechanics
8. 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 advisor, but these must be pre-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 advisor and the SE Graduate Affairs Committee). In general, no undergraduate courses are allowed for the M.S. degree. In special cases where an undergraduate course may be used, the arrangement must be preapproved by both the academic advisor and the Graduate Affairs Committee.

Units obtained in SE 290 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 a seminar course each quarter dealing with current research topics in Structural Engineering (SE 290). Students must take SE 290 every quarter in the first year, and are strongly recommended to take it for at least one quarter in every subsequent year.

FOCUS SEQUENCES

Structural Analysis

SE 201. Advanced Structural Analysis
SE 202. Structural Stability
SE 203. Structural Dynamics
SE 204. Advanced Structural Dynamics
SE 205. Nonlinear Mechanical Vibrations
SE 206. Random Vibrations

Structural Design

SE 211. Advanced RC/PC Design
SE 212. Advanced Structural Steel Design
SE 213. Bridge Design
SE 223. Advanced Seismic Design of Structures
SE 254. FRP Rehabilitation of Civil Structures

Computational Mechanics

SE 233. Computational Techniques in Finite Elements
SE 276A. Finite Element Methods in Solid Mechanics I
SE 276B. Finite Element Methods in Solid Mechanics II
SE 277. Error Control in Finite Element Analysis
SE 278A. Finite Element Methods for Computational Fluid Dynamics

Earthquake Engineering

SE 203. Structural Dynamics
SE 206. Random Vibrations
SE 221. Earthquake Engineering
SE 222. Geotechnical Earthquake Engineering
SE 223. Advanced Seismic Design of Structures
SE 243. Soil Structure Interaction

Geotechnical Engineering

SE 222. Geotechnical Earthquake Engineering
SE 241. Advanced Soil Mechanics
SE 242. Advanced Foundation Engineering
SE 243. Soil Structure Interaction

Advanced Composites

SE 253A. Mechanics of Laminated Composite Structures I
SE 253B.Mechanics of Laminated Composite Structures II
SE 253C. Mechanics of Laminated Anisotropy Plates and Shells
SE 252. Experimental Mechanics and NDE
SE 251A. Processing Science of Composites
SE 251B. Mechanical Behaviors of Polymers and Composites
SE 254. FRP Rehabilitation of Civil Structures

Solid Mechanics

SE 234. Plates and Shells
SE 235. Wave Propagation in Elastic Media
SE 252. Experimental Mechanics and NDE
SE 271. Solid Mechanics for Structural and Aerospace Engineering
SE 272. Theory of Elasticity
SE 273. Anelasticity

Advanced Structural Behavior

SE 205. Nonlinear Mechanical Vibrations
SE 224. Structural Reliability and Risk Analysis
SE 206. Random Vibrations
SE 252. Experimental Mechanics and NDE
SE 265. Structural Health Monitoring Principles

Students taking the Solid Mechanics focus sequence are required to take SE 271, SE 272, and one of these courses: SE 273, SE 252 or SE 235.

SE 207 Topics in Structural Engineering will be acceptable to use towards a focus sequence requirement pending petition and approval of the Graduate Affairs Committee (GAC).

Students taking the Advanced Composites focus sequence have the opportunity of taking either one or both of the following sequences:

Suggested Sequence A

SE 253A. Mechanics of Laminated Composite Structures I
SE 253B. Mechanics of Laminated Composite Structures II
SE 253C or other class approved by advisor

Suggested Sequence B

SE 253B. Mechanics of Laminated Composite Structures II
SE 251A. Processing Science of Composites
SE 251B or other class approved by advisor

Note: Students who have previously taken an equivalent course must choose suggested Sequence B.

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.

M.S. DEGREE IN STRUCTURAL ENGINEERING WITH SPECIALIZATION IN HEALTH MONITORING, PROGNOSIS, AND VALIDATED SIMULATIONS (SHMP&VS)

The M.S. degree in SHMP&VS provides specialized multidisciplinary knowledge in the three technology areas of (1) sensing technology, (2) data interrogation, and (3) predictive modeling. Many courses currently offered within the Jacobs School of Engineering may be grouped into numerous focus sequences within each technology area, as shown in the following list:

A. SENSING TECHNOLOGY AREA

Sensing Methodologies

SE 252. Experimental Mechanics and NDE

MAE 261. Sensors and Measurements
MAE 268. MEMS Materials, Fabrication, and Applications

Data Acquisition Systems

ECE 257B. Principles of Wireless Networks
ECE 258A-B. Digital Communications
ECE 259CN. Advanced Coding and Modulation for Digital Communications
MAE 261. Sensors and Measurements
CSE 237A. Introduction to Embedded Computing
CSE 237B. Software for Embedded Computing
CSE 237C. Validation/Testing of Embedded Systems
CSE 237D. Design Automation and Prototyping for Embedded Systems

Controls

MAE 280A. Linear Systems Theory
MAE 280B. Linear Control Design
MAE 282. Adaptive Control
MAE 284. Robust and Multi-Variable Control
MAE 285. Optimal Control and Estimation

B. DATA INTERROGATION TECHNOLOGY AREA

Signal Processing

ECE 161A/SIO 207A. Introduction to Digital Signal Processing
ECE 251AN/SIO 207B. Digital Signal Processing I
ECE 251BN/SIO 207C. Digital Signal Processing II
ECE 251CN. Filter Banks and Wavelets
ECE 251DN or SIO 207D. Array Processing
ECE 253A. Fundamentals of Digital Image Processing
ECE 253B. Digital Image Analysis
ECE 254. Detection Theory
ECE 255AN. Information Theory

System Identification

MAE 283A. Parameter Identification: Theory and Methods
MAE 283B. Approximate Identification and Control
ECE 256A-B. Time Series Analysis and Applications
ECE 275A. Parameter Estimation I
ECE 275B. Parameter Estimation II

Pattern Recognition

CSE 250A. Artificial Intelligence: Search and Reasoning
CSE 250B. Artificial Intelligence: Learning
CSE 253. Neural Networks for Pattern Recognition
CSE 254. Statistical Learning
CSE 255. Data Mining and Artificial Intelligence Applications
ECE 270A-B-C. Neurocomputing

Statistical/Probabalistic Methods

MTH 281A-B-C. Mathematical Statistics
CSE 254. Statistical Learning
SE 206. Random Vibrations
SE 224. Structural Reliability and Risk Analysis

C. PREDICTIVE MODELING TECHNOLOGY AREA

Structural Analysis

SE 201. Advanced Structural Analysis
SE 202. Structural Stability
SE 203. Structural Dynamics
SE 204. Structural Reliability and Risk Analysis

Finite Element

MAE 232A. Finite Element Methods in Solid Mechanics I
MAE 232B. Finite Element Methods in Solid Mechanics II
MAE 232C. Advances in Materials Computations
SE 274. Nonlinear Finite Elemental Methods

Solid Mechanics

SE 271. Solid Mechanics for Structural and Aerospace Engineering
SE 272. Theory of Elasticity
SE 273. Theory of Plasticity and Viscoelasticity
SE 252. Experimental Mechanics and NDE
SE 235. Wave Propagation in Elastic Media

Material Behavior/Modeling

MAE 233B. Micromechanics
MAE 233C. Advanced Mechanics of Composite Materials
MAE 232C. Advances in Materials Computations
MAE 250. Fatigue, Fracture, and Failure Analysis in Engineering Materials
MAE 273A. Dynamic Behavior of Materials
SE 245. Constitutive Modeling and Numerical Implementation

Advanced Structural Behavior

SE 205. Nonlinear Mechanical Vibrations
SE 206. Random Vibrations
SE 224. Structural Reliability and Risk Analysis
SE 252. Experimental Mechanics and NDE
SE 265. Structural Health Monitoring Principles

Earthquake Engineering

SE 203. Structural Dynamics
SE 206. Random Vibrations
SE 221. Earthquake Engineering
SE 222. Geotechnical Earthquake Engineering
SE 223. Advanced Seismic Design of Structures

Advanced Composites

SE 142. Design of Composite Structures
SE 251. Processing Science of Composites
SE 253. Mechanics of Laminated Composite Structures
MAE 233C. Advanced Mechanics of Composite Materials
SE 254. FRP Rehabilitation of Civil Structures

Two degree plans in SHMP&VS will be offered: M.S. Thesis Plan and M.S. Comprehensive Examination Plan. Students in both plans must complete forty-eight units of credit for graduation. For both plans, students must complete thirty-six units of course work consisting of one focus sequence from each of the three technology areas A, B, and C listed above. Any three of the courses listed under a specific topic area constitute a focus sequence. Courses must be chosen in consultation with the student's advisor. The remaining twelve units must be completed as graduate research SE 299.

For the M.S. SHMP&VS Comprehensive Examination Plan, the twelve-unit graduate research SE 299 must be conducted as a mentored research project. This project is intended to provide a mentored practicum whereby students integrate knowledge learned from their technology areas into comprehensively solving a problem from structural health monitoring/prognosis or model validation and uncertainty quantification, at their discretion. This project will emphasize professional practice, with both oral and written communication of technical data, and will include a strong design component. The project will be presented to a committee of two faculty members in Structural Engineering and one from another department within the Jacobs School of Engineering or an adjunct faculty member in an appropriate area of focus.

For the M.S. SHMP&VS Thesis Plan, the twelve-unit graduate research SE 299 culminates with the preparation of a research thesis. The thesis must be successfully defended in an oral examination and public presentation conducted by a committee composed of three faculty members. The committee will consist of two faculty members in Structural Engineering and one from another department within the Jacobs School of Engineering or an adjunct faculty member in an appropriate area of focus. A complete copy of the student's thesis must be submitted to each member of the M.S. thesis committee at least two weeks prior to the defense.

Because of the inherent multidisciplinary nature of the M.S. SHMP&VS degree, research within SE 299 can be conducted at outside locations (industry or government facilities). In this case a scientist on location, with an adjunct faculty appointment at UCSD, will be part of the student's committee.

All students in the M.S. SHMP&VS program are required to take a seminar course (SE 290) each quarter they are registered.

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 advisors, 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 a seminar course each quarter dealing with current research topics in Earthquake Engineering (SE 290) . Students must take SE 290 every quarter in the first year of graduate study, and it is strongly recommended to take it for at least one quarter in every subsequent year.

All doctoral students will be required to take SE 200, Applied Mathematics in Structural Engineering, prior to taking the departmental comprehensive exam.

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. An update list of sample focus areas for Ph.D. students is available in the Structural Engineering Graduate Handbook. 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 the Department of 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 251BN, 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 Structural Engineering 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 in focus areas offered or approved by the department. A list of focus areas is available in the Structural Engineering Graduate Handbook. 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 serving as a teaching assistant or by taking SE 501 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 advisor, 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 of 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 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 department faculty members 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

For course descriptions not found in the UC San Diego General Catalog, 2010–11, please contact the department for more information.

All undergraduate 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, structural engineering students. 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 courses may be offered more than once each year, most SE 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.

Program and or materials fees may apply to those courses with large lab components.

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. 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 9. Algorithms and Programming for Structural Engineering (4)
Introduction to the Mathlab environment. Variables and types, statements, functions, blocks, loops, and branches. Algorithm development. Functions, function handles, input and output arguments. Data encapsulation and object-oriented programming. Toolboxes and libraries. Models from physics (mechanics and thermodynamics) are used in exercises and projects. **Prerequisites:** grade of C– or better in Math. 20D and Math. 20F (20F may be concurrent).

SE 10A. Design Competition—Design, Build, and Fly Aircraft (1)
Student teams design, build, and fly unmanned aircraft for a national student competition. Students concentrate on vehicle system design including aerodynamics, structures, propulsion, and performance. Teams engineer and fabricate the aircraft, submit a design report, and prep aircraft for competition. **Prerequisite:** consent of instructor.

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:** grade 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. Newton's equations of motion. Energy and momentum methods. Impulsive motion and impact. Systems of particles. Kinetics and kinematics of rigid bodies in 2-D. Introduction to 3-D dynamics of rigid bodies. **Prerequisites:** grades of C– or better in 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 Math. 20F and SE 101B (or MAE 130B).

SE 102. Numerical, Computational, and Graphical Tools for Structural Engineering I (4)
Numerical methods for initial value problems. Errors, Taylor series. Convergence. Solutions of linear equations. Gaussian elimination, multiplicative decomposition. Matlab is used for programming exercises and projects. **Prerequisites:** grade of C– or better in SE 1, SE 9, and SE 101A (or MAE 130A).

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 9, and SE 101A (or MAE 130A).

SE 110A. Solid Mechanics I (4)
Concepts of stress and strain. Hooke's law. Axial loading of bars. Torsion of circular shafts. Shearing and normal stresses in beam bending. Deflections in beams. Statically determinate and indeterminate problems. Combined loading. Principal stresses and design criteria. Buckling of columns. Students may not receive credit for SE 110A or MAE 131A and SE 110A/MAE 131A. **Prerequisites:** grade of C– or better in Math. 20D and SE 101A (or MAE 130A).

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. **Prerequisites:** grade of C– or better in SE 110A (or MAE 131A), SE majors.

SE 111A–B. Steel Bridge Design Competition (2-2)
Student teams design, test, and build a steel bridge for regional and national ASCE design competition. Students focus on learning ASCE guidelines, rules, and constraints for adherence to national competition policy. **Prerequisites:** grade of C– or better in SE 103 and SE 110A (or MAE 131A). SE 111A for SE 111B.

SE 112A–B. Concrete Canoe Design Competition (2-2)
Student teams design, test, and build a concrete canoe for regional and national ASCE design competition. Students focus on learning and applying specific fundamental ASCE competition rules, guidelines, and constraints into design. **Prerequisites:** grade of C– or better in SE 110A (or MAE 131A). SE 112A for SE 112B.

SE 115. Fluid Mechanics for Structural Engineering (4)
Fluid statics, hydrostatics; integral and differential forms of conservation equations for mass, momentum, and energy; Bernoulli equation; dimensional analysis; viscous pipe flow; external flow, boundary layers; open channel flow. **Prerequisites:** grade of C– or better in Phys. 2A, Math. 20D, and Math. 20E.

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 SE 102 and SE 103, SE 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, 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. **Prerequisites:** SE 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 110A (or MAE 131A). 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 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 121, SE 130B, and SE 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. Program and or materials fee may apply. **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:** SE 110A (or MAE 131A) and SE 110B.

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. Design of Reinforced Concrete (4)
Concrete and reinforcement properties. Service and ultimate limit state analysis and design. Design and detailing of structural components. **Prerequisites:** grade of C– or better in SE 103 and SE 130A.

SE 151B. Design of Prestressed Concrete (4)
Time-dependent and independent properties of concrete and reinforcing material. Concept and application of prestressed concrete. Service and ultimate limit state analysis and design of prestressed concrete structures and components. Detailing of components. Calculation of deflection and prestress losses. Prerequisite: grade of C– or better in SE 151A.

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 150, and SE 151A; concurrent enrollment in SE 151B.

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 Mechanics I (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 enrollment given to engineering majors.

SE 160B. Aerospace Structural Mechanics II (4)
Work-energy principles, matrix models, bending of plates and shells, structural stability of beams and plates, tension field beams, wing divergence and control reversal, vibration damping and flutter, fasteners and structural joints, structural test methods. **Prerequisites:** grade of C– or better in SE 160A. Priority enrollment given to 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 168. Structural System Testing and Model Correlation (4)
Dynamic/model testing of structures: test planning/execution, actuation, sensing, and data acquisition, signal processing, data conditioning, test troubleshooting. Methods of updating finite element structural models to correlate with dynamic test results. Model/test correlation assessment in industrial practice. Knowledge of MATLAB strongly encouraged. Prerequisites: grade of C– or better in SE 101C (or MAE 130C) and SE 131.

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 130A-B, SE 151A.

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 130B or SE 160B.

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 183/246. Engineering Geology (4)
Influence of geology on design of engineering works. Mineral and rock identification and their engineering behavior. Geologic mapping. Rock mechanics, rock slope stability, and tunnel engineering. Local field trips. **Prerequisites:** senior standing; priority enrollment is given to structural engineering majors; graduate standing required for SE 246.

SE 192. Senior Seminar (1)
The Senior Seminar is designed to allow senior undergraduates to meet with faculty members to explore an intellectual topic in structural engineering. Topics will vary from quarter to quarter. Enrollment is limited to twenty students with preference given to seniors. **Prerequisites:** SE major. Department stamp and/or consent of instructor.

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 (1–4)
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 200. Applied Mathematics in Structural Engineering (4)
This course is designed to give beginning graduate students the basic preparation in mathematical methods required for graduate Structural Engineering courses. Topics include systems of linear algebraic equations; ordinary differential equations; diffusion and wave propagation problems; and calculus variation. **Prerequisite:** graduate standing.

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, Lagrange's equations. Linearization of the equations of motion. Free and forced vibrations. Normal mode and frequency response method. **Prerequisite:** graduate standing 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 integral formulations of the eigenvalue problem. Perturbation and iteration methods. Introduction to nonlinear vibrations structural control. **Prerequisite:** graduate standing.

SE 205. Nonlinear Mechanical Vibrations (4)
Advanced analytical techniques to understand nonlinearity in mechanical vibration. Phase plane analysis instability, and bifurcations. Application in nonlinear structural resonance. Introduction to chaotic dynamics, advanced time series analysis, and using chaotic dynamics in applications such as structural damage assessment. **Prerequisite:** SE 206 or consent of instructor.

SE 206. Random Vibrations (4)
Introduction to probability theory and random processes. Correlation and power spectral density functions. Estimation of correlation functions, ergodicity. Stochastic dynamic analysis of structures subjected to stationary and non-stationary fandom excitations. Crossings, first-escursion probability, distributions of peaks and extremes.

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. **Prerequisite:** SE 151A, or equivalent background in basic RC/PC design, or consent of instructor.

SE 212. Advanced Structural Steel Design (4)
Load and Resistance Factor Design (LRFD) philosophy. Behavior and design of steel elements for global and local buckling. Background of seismic codes. Ductility requirements and capability design concept. Seismic design of steel moment frames and braced frames. **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 unreinforcced and reinforced masonry structure 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 151A, B, or equivalent basic reinforced concrete course, or consent of instructor; graduate standing.

SE 215. Cable Structures (4)
The course deals with cable structures from a structural mechanics point of view. The theoretical and practical aspects of the application of cables to moorings, guyed structures, suspension bridges, cable-stayed bridges, and suspended membranes are discussed. **Prerequisite:** graduate standing or consent of instructor.

SE 220. Seismic Isolation and Energy Dissipation (4)
Concepts, advantages and limitations of seismic isolation techniques; fundamentals of dynamic response under seismic excitation; spectral analysis; damping; energy approach; application to buildings and structures. **Prerequisite:** background in structural dynamics, 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)
Fundamental concepts in seismic design. Innovative earthquake resistant system. Passive energy dissipation systems. Metallic, friction, viscoelastic dampers. Self-centering devices. Tuned-mass dampers. Theory of seismic isolation. Metallic bearings. Lead-extrusion bearings. Sliding bearings. Laminated rubber bearings. Lead-rubber bearings. **Prerequisite:** graduate standing.

SE 224. Structural Reliability and Risk Analysis (4)
Probability theory and random processes; fundamentals of structural reliability theory. Modern methods of structural reliability analysis including computational aspects; structural component and system reliability. Reliability-based design codes; structural modeling for performance and safety. Risk analysis of structural systems. **Prerequisite:** basic knowledge of probability theory (e.g., SE 125)

SE 233. Computational Techniques in Finite Elements (4)
Practical application of the finite element method to problems in solid mechanics including basic preprocessing and postprocessing. Topics include element types, mesh refinement, boundary conditions, dynamics, eigenvalue problems, and linear and nonlinear solution methods.

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; shell of revolution; shallow shells; selected static and dynamic problems; survey of recent advances. **Prerequisite:** graduate student standing.

SE 235. Wave Propagation in Elastic Media (4)
Wave propagation in elastic media with emphasis on waves in unbound media and on uniform and layered half-spaces. Fundamental aspects of elastodynamics. Application to strong-motion seismology, earthquake engineering, dynamics of foundations, computational wave propagation, and non-destructive evaluations. **Prerequisite:** graduate standing or consent of instructor.

SE 236. Wave Propagation in Continuous Structural Elements (4)
Propagation of elastic waves in thin structural elements such as strings, rods, beams, membranes, plates and shells. An approximate strength-of-materials approach is used to consider propagation of elastic waves in these elements and obtain the dynamic response to transient loads. **Prerequisite:** graduate standing or consent of instructor.

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 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.

SE 246. Engineering Geology (4)
Influence of geology on design of engineering works. Mineral and rock identification and their engineering behavior. Geologic mapping. Rock mechanics, rock slope stability, and tunnel engineering. Local field trips. (Graduate students are required to submit a term project based on two extended weekend field trips and self-guided research.)

SE 251A. 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. **Prerequisite:** graduate standing.

SE 251B. Mechanical Behaviors of Polymers and Composites (4)
Material science oriented course on polymers and composites. Mechanical properties of polymers; micromechanisms of elastic and plastic deformations, fracture, and fatigue of polymers and composites. Graduate student standing required.

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 instructor.

SE 253A. Mechanics of Laminated Composite Structures I (4)
Graduate-level introductory course on mechanics of composites and anisotropic materials. Overview of composite materials and processes, 3-D properties and stress-strain relationships, micromechanics, classical laminated plate theory, basic failure criteria, thermal/moisture/CTE. Students may not receive credit for both SE 253A and SE 250. **Prerequisite:** graduate standing.

SE 253B. Mechanics of Laminated Composite Structures II (4)
Advanced topics, with prerequisite being SE 253A, or equivalent. 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, advanced failure theories, fracture, holes/notches and hole-size effect, interlaminar stresses, free-edge problems, impact, damage tolerance, fatigue, elastic tailoring, thermally stabile/zero CTE structures, etc. **Prerequisites:** SE 253A or equivalent, graduate standing.

SE 253C. Mechanics of Laminated Anisotropy Plates and Shells (4)
Static, dynamic, and elastic stability of laminated anisotropic plates and cylindrical shells. Theories covered include thin-plate (classical lamination theory), first- and third-order shear-deformable (Reissner-Mindlin, and Reddy) thick plates, and refined layer-wise theories. Solution methods covered include exact, approximate (Ritz, Galerkin) and the finite element method. Additional topics include sandwich construction, elastic couplings, theormal response, shear factor determination, fiber and interlaminar stress recovery, strength, and safety considerations. **Prerequisites:** graduate student standing required; must have taken SE 253B or equivalent, or consent of instructor.

SE 254. FRPs in Civil Structures (4)
Strengthening of existing reinforced concrete structures with fiber reinforced composites. Mechanics of Fiber Reinforced Plastic lamina, bond strength of FRP-to-concrete joints, shear and flexural strengthening of beams and walls, increased strength and ductility of axially loaded columns, and seismic retrofit of columns. **Prerequisites:** SE 142 Design of Composite Structures or equivalent, SE 251A Processing Science of Composites.

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 265. 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, data normalization, and statistical modeling will be introduced in an integrated context. MATLAB-based exercises. Term project. **Prerequisites:** graduate student, undergraduate vibrations or structural dynamics course.

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. **Prerequisite:** 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. **Prerequisite:** SE 271 or consent of instructor.

SE 273. Anelasticity (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. **Prerequisites:** graduate standing and SE 271 and SE 272, or MAE 231A and MAE 231B, or consent of instructor.

SE 274. Nonlinear Finite Element Methods for Solid Mechanics (4)
Modeling of mechanical deformation processes in solids and structures by the finite element method. PDE models of deformations in solids and structures. Weak form. Weighted residual method. Material models for 3D solids and rods, beams, shells: elasticity, plasticity, viscoplasticity. **Prerequisite:** graduate standing.

SE 275. Hydrodynamics in Marine Engineering (4)
Fluid dynamics equations; potential flow-theory; basic potential-flow solutions; added mass; 6-DOF hydrodynamic forces/moments on a body; water wave theory; irregular wave field; wave-body interactions; high/low-frequency responses; vortex-induced vibrations; galloping; numerical methods. **Prerequisite:** graduate standing.

SE 276A. Finite Element Methods in Solid Mechanics I (4)
Finite element methods for linear problems in solid mechanics. Emphasis on the principle of virtual work, finite element stiffness matrices, various finite element formulations and their accuracy and the numerical implementation required to solve problems in small strain, isotropic elasticity in solid mechanics.

SE 276B. Finite Element Methods in Solid Mechanics (4)
Finite element methods for linear problems in structural dynamics. Beam, plate, and doubly curved shell elements are derived. Strategies for eliminating shear locking problems are introduced. Formulation and numerical solution of the equations of motion for structural dynamics are introduced and the effect of different mass matrix formulations on the solution accuracy is explored.

SE 276C. Finite Element Methods in Solid Mechanics III (4)
Finite element methods for problems with both material and geometrical (large deformations) nonlinearities. The total LaGrangian and the updated LaGrangian formulations are introduced. Basic solution methods for the nonlinear equations are developed and applied to problems in plasticity and hyperelasticity. **Prerequisites:** graduate standing and SE 276A or MAE 232A and MAE 231A or SE 271.

SE 277. Error Control in Finite Element Analysis (4)
This course will provide an overview of the latest technology for evaluating and improving the accuracy and validity of linear and nonlinear finite element models, solution verification, finite element model validation, sensitivity analysis, uncertainty analysis, and test-analysis correlation. **Prerequisite:** SE 232B or MAE 232B.

SE 278A. Finite Element Methods for Computational Fluid Dynamics (4)
Development and application of advanced computational techniques for fluid flow. Stabilized and variational multiscale methods for finite element and related discretizations are stressed. Applications involve advection-diffusion equations and systems, and incompressible and compressible Navier-Stokes equations. Turbulence modeling will also be covered. **Prerequisite:** MAE 232A or SE 276A or consent of instructor.

SE 278B. Computational Fluid-Structure Interaction (4)
Conservation laws on general moving domains. Arbitrary Lagrange-Eulerian (ALE) and space-time approaches to fluid-structure interaction are covered. Suitable discretizations, mesh motion, and discrete solution strategies are discussed. **Prerequisite:** SE 278A.

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. (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. **Prerequisites:** consent of instructor and the department. (S/U grades permitted.)