UC San Diego

Structural Engineering

JACOBS SCHOOL OF ENGINEERING

Structural Engineering Graduate Handbook

2017-18

Department of Structural Engineering

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THE STRUCTURAL ENGINEERING PROGRAM

The Department of Structural Engineering at the University of California at San Diego offers a unique program that crosses different engineering disciplines, including civil, geotechnical, mechanical, aerospace, biological, and marine/offshore engineering, with a focus on structural design and analysis, structural materials, computational mechanics, and solid mechanics. This broad-based cross-disciplinary structural engineering approach allows not only diversity in the selection of graduate courses but also a diversity of employment opportunities across the engineering spectrum.

The program is tailored towards the common needs and reliance of different engineering fields on the knowledge and advances in materials engineering, classical structural mechanics theories, computational and numerical analysis tools, experimental structural analysis, and structural health monitoring for applications ranging from nano-structures to large-scale civil infrastructure systems. While providing training on the fundamentals, the program offers specialization within a chosen area through a sequence of discipline specific courses. In particular, the Structural Engineering program offers the opportunity for further education in one or more of the following five primary focus areas that are intimately tied to the current research activities in the Department: (1) Earthquake Engineering, (2) Advanced Composites and Aerospace Structural Systems, (3) Renewal Engineering, (4) Structural Health Monitoring, Prognosis and Validated Simulations, and (5) Computational Mechanics.

Unique education and research opportunities are provided by faculty expertise across a range of specialties in materials and structural systems of different types and scales, and through the specially designed laboratories including the world-renowned Charles Lee Powell Structural Research Laboratories. This unique facility consists of a set of large-scale testing laboratories where full-scale structural systems ranging from bridges and buildings, ship hulls and deck structures, to aircraft wings and structural systems can be tested using state-of-the-art computer-controlled equipment. The Structural Systems Laboratory houses a 15-m tall reaction wall and a 37-m long strong floor, while the Structural Components Laboratory has a 9-m tall by 19-m wide strong wall with a 14.3 by 21.3-m strong floor, and the Composites Structures Laboratory has a 9-m tall by 5.5-m wide strong wall with a 14.3 by 7.2-m strong floor. The facility also includes a

high-capacity shake table and a geotechnical laboratory including a centrifuge and soil boxes. The research facilities also include state-of-the-art nano-materials characterization facilities, polymer and composite characterization and processing laboratories, composites and aerospace structures laboratories, non-destructive evaluation laboratories, structural dynamics laboratory, a unique 6-DOF seismic response modification device test facility, and other unique facilities. The Englekirk Structural Engineering Center is equipped with the world's first outdoor shake table adjacent to the country's largest soil-structure interaction test facility, allowing researchers to perform dynamic earthquake safety tests on full-scale structural systems. It also houses a blast simulator, which is the world's first facility designed to study structural response to, and damage caused by, bomb blasts without creating actual explosions. Besides enabling one-of-a-kind experiments, the laboratory facilities enable the validation of sophisticated design and analysis models, which are subsequently used for design, numerical prediction, and detailed parametric studies. Thus, a complete systems approach from materials development and large-scale experiments to implementation of sensor networks and development of design recommendations and nonlinear analytical models is typical for research projects in the Department.

Close industrial ties exist between UCSD Structural Engineering faculty and the civil, aerospace, and marine engineering communities. The program is also strengthened by close ties with UCSD's Scripps Institution of Oceanography, the California Space Institute, the San Diego Supercomputer Center, the Environmental Sciences Initiative, and the Los Alamos National Laboratory (LANL). The Department is responsible for a significant portion of the UCSD/LANL Research and Educational Collaboration, a program unique in the Nation that combines UCSD and LANL expertise in specific research areas. These collaborations, in combination with the Powell Structural Research Laboratories, provide a unique research environment for graduate students and faculty alike.

THE GRADUATE PROGRAM

M.S. DEGREE IN STRUCTURAL ENGINEERING

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 coursework. In addition to the traditional M.S. degree in Structural Engineering, there is an M.S. degree with specialization in Structural Health Monitoring and Non-Destructive Evaluation (SHM &NDE). The requirements for the M.S. degree in SHM&NDE are listed in a separate section of this handbook. Two M.S. degree plans are offered, the M.S. Thesis Plan and the M.S. Comprehensive Examination Plan.

The MS 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 MS Thesis Plan and the MS Comprehensive Examination Plan, are offered. The MS 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 MS Thesis Plan involves course work leading to the completion and defense of a master's thesis. The MS Comprehensive Examination Plan involves course work and requires the completion of a written comprehensive examination covering multiple courses that the student has taken. The MS 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.

MS students will be required to complete two out of seven core course electives. The courses are SE 200, SE 201A, SE 202, SE 203, SE 241, SE 271, SE 233, or SE 276A. They can be counted towards a focus sequence or a technical elective.

MS students must complete forty-eight units of credit for graduation. For the MS Comprehensive Examination Plan all forty-eight units of credit must consist of regular courses (twelve courses). For the MS 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 MS 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) Structural Health Monitoring

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 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 adviser and the SE Graduate Affairs Committee). In special cases where an undergraduate course may be used, the arrangement must be preapproved by both the academic adviser 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.

A faculty advisor will be assigned for each student during their first quarter. The faculty advisor will assist students with their academic plans and any other questions they may have.

For both M.S. plans, students are required to complete a minimum of two focus sequences. Any three of the courses listed under a specific topic area constitute a focus sequence.

The focus sequences are listed below:

Structural Analysis

SE 201A Advanced Structural Analysis

SE 201B Nonlinear Structural Analysis

SE 202 Structural Stability

SE 203 Structural Dynamics

SE 204 Advanced Structural Dynamics

SE 206 Random Vibrations

SE 205 Nonlinear Mechanical Vibrations

SE 215 Cable Structures

SE 224 Structural Reliability and Risk Analysis

SE 233 Computational Techniques in Finite Elements

Computational Mechanics and Finite Elements

SE 233 Computational Techniques in Finite Elements

SE 274 Nonlinear Finite Element Methods

SE 276A Finite Element Methods in Solid Mechanics I

SE 276B Finite Element Methods in Solid Mechanics II

SE 276C Finite Element Methods in Solid Mechanics III

SE 277 Error Control in Finite Element Analysis

SE 278A Computational Fluid Dynamics

SE 278B Computational Fluid-Structure Interaction

SE 279 Meshfree Methods for Linear and Nonlinear Mechanics

SE 280. Finite Element Computations in Solid Mechanics

Structural Design

SE 151B Design of Prestressed Concrete

SE 211 Advanced Reinforced & Prestressed Concrete Design

SE 212 Advanced Structural Steel Design

SE 213 Bridge Design

SE 214 Masonry Structures

SE 220 Seismic Isolation and Energy Dissipation

SE 223 Advanced Seismic Design of Structures

SE 224 Structural Reliability and Risk Analysis

SE 254. FRP Rehabilitation of Civil Structures

Earthquake Engineering

SE 203 Structural Dynamics

SE 206 Random Vibrations

SE 220 Seismic Isolation and Energy Dissipation

SE 221 Earthquake Engineering

SE 222 Geotechnical Earthquake Engineering

SE 223 Advanced Seismic Design of Structures

SE 243 Soil-structure Interaction

Advanced Composites

SE 251A Processing Science of Composites

SE 251B Mechanical Behaviors of Polymers & Composites

SE 252 Experimental Mechanics and NDE

SE 253A Mechanics of Laminated Comp. Structures I

SE 253B Mechanics of Laminated Comp. Structures II

SE 253C Mechanics of Laminated Anisotropy Plates & Shells

SE 260A Aerospace Structural Mechanics I

SE 260B Aerospace Structural Mechanics II

SE 262 Aerospace Structures Repair

Geotechnical Engineering

SE 222 Geotechnical Earthquake Engineering

SE 241 Advanced Soil Mechanics

SE 242 Advanced Foundation Engineering

SE 243 Soil-structure Interaction

SE 244 Numerical Methods in Geomechanics

SE 247 Ground Improvement

SE 248. Engineering Properties of Soils

SE 250 Stability of Earth Slopes & Retaining Walls

Solid Mechanics

SE 234 Plates and Shells (or MAE equivalent)

SE 235. Wave Propagation in Elastic Media

SE 252. Experimental Mechanics and NDE

SE 271 Solid Mechanics for Structural & Aerospace Engineering

SE 272 Theory of Elasticity

SE 273 Inelasticity

Structural Health Monitoring

SE 202 Structural Stability

SE 204 Advanced Structural Dynamics

SE 205 Nonlinear Mechanical Vibrations

SE 206 Random Vibrations

SE 224 Structural Reliability and Risk Analysis

SE 252 Experimental Mechanics and NDE

SE 263. Non-destructive Evaluation

SE 265 Structural Health Monitoring Principles

SE 266. Smart and Multi-functional Materials

SE 267. Sensor and Data Acquisition

SE 268 Structural System Testing and Model Correlation

***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).*

The thesis defense is the final examination for students enrolled in the M.S. Thesis Plan and must be conducted after completion of all coursework. 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 members. A complete copy of the student's thesis must be submitted to each committee member a minimum of two weeks prior to the defense.

MS in Structural Engineering with Specialization in Health Monitoring and Non-destructive Evaluation (SHM&NDE)

*****Pending WASC Approval*****

The Master of Science in structural engineering with specialization in structural health monitoring and non-destructive evaluation (SHM&NDE) provides highly interdisciplinary knowledge incorporating three broad technology areas: (1) sensing technology, (2) data interrogation, and (3) modeling and analysis. The intersections and integration of these technology areas are fundamental to supporting structural health monitoring and nondestructive evaluation, which may be defined as the process of making an uncertainty-quantified assessment, based on appropriate analyses of in-situ measured data, about the current ability of a structural component or system to perform its intended design function(s) successfully. This discipline within structural, civil, mechanical, and aerospace engineering is a fundamental capability that supports "design-to-retirement" life cycle management of systems.

SE 266. Smart and Multifunctional Materials

SE 267. Sensors and Data Acquisition for Structural Engineering

SE 268. Structural System Testing and Model Correlation

CSE 237A. Introduction to Embedded Computing

ECE 257B. Principles of Wireless Networks

Two degree options in SHM&NDE will be offered: MS Thesis option and MS Comprehensive Examination option. Students in both plans must complete thirty-six units of credit for graduation. For both options, students must complete two core courses, SE 263, Non-destructive

Evaluation, and SE 265, Structural Health Monitoring Principles (eight total units). Additionally, the MS SHM&NDE Thesis plan involves regular course work (twenty units) and graduate research (eight units) leading to the completion and defense of a master's thesis. Correspondingly, the MS Comprehensive Examination plan involves regular course work (twenty-four units) and a mentored independent study (SE 296) capstone course. The comparative distribution of units for each of the two degree options is shown in the table below:

Requirement	**Thesis option (units)**	**Comprehensive option (units)**
Core course	SE 263. Non-destructive Evaluation (**4**) SE 265. Structural Health Monitoring Principles (**4**)	SE 263. Non-destructive Evaluation (**4**) SE 265. Structural Health Monitoring Principles (**4**)
Capstone experience	No requirement	SE 296. Independent Study or approved equivalent (**4**)
Thesis research	SE 299. Graduate Research (**8**)	No requirement
Focus sequence 1	One from Focus Area 1 (**4**)	One from Focus Area 1 (**4**)
Focus sequence 2	Two from Focus Area 2 (**8**)	Two from Focus Area 2 (**8**)
Focus sequence 3	Two from Focus Area 3 (**8**)	Two from Focus Area 3 (**8**)
Technical elective	No requirement	One from Technical Elective (**4**)
Total units	**36**	**36**

Many courses currently offered within the Jacobs School of Engineering may be grouped into the three focus areas comprising each technology area described above, as shown in the following list:

A. Sensing Technology (Focus Area 1)

SE 252. Experimental Mechanics and NDE

SE 264. Sensors and Data Acquisition for Structural Engineering

SE 266. Smart and Multifunctional Materials

SE 268. Structural System Testing and Model Correlation

CSE 237A. Introduction to Embedded Computing

ECE 257B. Principles of Wireless Networks

B. Data Interrogation (Focus Area 2)

SE 207. Diagnostic Imaging

ECE 251A. Digital Signal Processing I

ECE 251B. Digital Signal Processing II

ECE 251C. Filter Banks and Wavelets

ECE 253. Fundamentals of Digital Image Processing

ECE 254. Detection Theory

SE 268. Structural System Testing and Model Correlation

MAE 283A. Parametric Identification: Theory and Methods

CSE 254. Statistical Learning

CSE 255. Data Mining and Predictive Analytics

CSE 250A. Principles of Artificial Intelligence: Probabilistic Reasoning and Learning

CSE 250B. Principles of Artificial Intelligence: Learning Algorithms

ECE 271A. Statistical Learning I

ECE 271B. Statistical Learning II

C. Modeling and Analysis (Focus Area 3)

SE 207. Fracture Mechanics and Failure Mechanisms [1–2]

SE 207. Validation and Verification of Computational Models

SE 202. Structural Stability

SE 203. Structural Dynamics

SE 205. Nonlinear Mechanical Vibrations

SE 206. Random Vibrations

SE 224. Structural Reliability and Risk Analysis

SE 233. Computational Techniques in Finite Elements or SE 276A. Finite Elements in Solid Mechanics I

SE 235. Wave Propagation in Elastic Media or MAE 238. Stress Waves in Solids

SE 236. Wave Propagation in Continuous Structural Elements

SE 253A. Mechanics of Laminated Composite Structures I

SE 262. Aerospace Structures Repair

SE 254. FRPs in Civil Structures

SE 268. Structural System Testing and Model Correlation

Additionally, the technical elective course required for the Comprehensive option may be chosen from any of the focus area lists above (provided it is not being counted as a focus area requirement), or from this additional preapproved list of courses:

SE 200. Applied Mathematics in Structural Engineering

SE 253B. Mechanics of Laminated Composite Structures II

MAE 273A. Dynamic Behavior of Materials

SE 201A. Advanced Structural Analysis

SE 260. Aerospace Structural Mechanics I

ECE 250. Random Processes

SE 204. Advanced Structural Dynamics

SE 276B. Finite Elements in Solid Mechanics II

ECE 241D. Array Processing

SE 234. Plates and Shells

MAE 208. Mathematics for Engineers

ECE 255AN. Information Theory

MAE 272. Imperfections in Solids

ECE 272A. Stochastic Processes in Dynamic Systems

ECE 275A. Parameter Estimation I

CSE 250C. Machine Learning Theory

For the MS Thesis option, the eight-unit graduate research (SE 299) culminates with the preparation of a written 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 three faculty members, one with expertise in each of the three focus areas. A complete copy of the student's thesis must be submitted to each member of the MS thesis committee at least two weeks prior to the defense.

For the MS Comprehensive option, the four-unit independent study (SE 296) must be conducted as a capstone experience project. This project is intended to provide a mentored project whereby students integrate knowledge learned from their technology areas into solving a problem from structural health monitoring/prognosis or nondestructive evaluation. The specific deliverables associated with the capstone project experience will be proposed by the student together with the SE 296 mentor and will be approved by the director of the MS program by the end of the quarter preceding the one in which the students intends to register in SE 296. The deliverables will be delivered to the SE 296 mentor, assessed by the mentor, and both the deliverables and assessment will be submitted to the director of the MS program for final approval.

Because of the inherent interdisciplinary nature of the MS SHM&NDE program, research within SE 296 or SE 299 may be conducted at outside locations (industry or government facilities). In this case a scientist or engineer on location, with an adjunct faculty appointment at UC San

Diego, will be identified as the SE 296 mentor or the SE 299 adviser and who will also be a member of the thesis committee.

All students in this degree program, for both degree options, must register in SE 290, Seminar, for any two quarters while enrolled in the program.

PH.D. DEGREE IN STRUCTURAL ENGINEERING

The Ph.D. program is intended to prepare students for 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. Dependent 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 Ph.D. Comprehensive 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.

It is also recommended that all Ph.D. students enroll in SE 290 every quarter in the first year, and are strongly recommended to take it for at least one quarter in every subsequent year. All doctoral students are strongly recommended to take SE 200, Applied Mathematics in Structural Engineering prior to taking the departmental comprehensive exam. Applied mathematics (SE200 or equivalent) may also be covered in the oral exam.

Doctoral Examinations:

A Structural Engineering Ph.D. student is required to pass three examinations. The first one is the **Departmental Comprehensive Examination**, which should be taken after three to six quarters of full-time graduate study with a minimum GPA of 3.5. This examination is intended to determine the candidate's ability to successfully pursue a research project at a level appropriate for the doctorate. It is administered by at least four faculty members, three of whom must be in Structural Engineering.

Although the student may elect to satisfy one examination area by course work, he or she is responsible for material pertaining to four focus areas. In order to satisfy an area by course work, all the courses in that area must have been taken at UCSD, the grade in each course must be no lower than a B, and the overall GPA in that area must be a minimum of 3.5. To ensure 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 interest, (b) one focus area, usually 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 Graduate Affairs Committee. Example focus areas for the Departmental Comprehensive Examination are listed at the end of this section. Students intending to specialize in the emerging areas of structural health monitoring, damage diagnostics and prognosis, and validated simulations are advised to take courses in the focus areas of Advanced Structural Behavior. Outside courses within the three Technology Areas of Sensing, Data Interrogation, and Predictive Modeling listed earlier can also be used to satisfy the outside Structural Engineering requirement. In addition, the Department has opportunities for select students in these areas to participate in special seminars, reviews, and research at leading collaborating institutes and laboratories such as the Los Alamos National Laboratories.

Since the examination areas must be approved by the 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 examination, the scope of the examination in each area is associated with a set of three graduate courses, generally focus areas 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 oral examination, at the discretion of the committee.

The Ph.D. Candidacy Examination is the second examination required of Structural Engineering doctoral students. Teaching Experience is required of all Structural Engineering Ph.D. students prior to taking the Ph.D. Candidacy Examination. The 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 teaching assistant service or by taking SE 501 for academic credit (SE 501). Students must contact the Graduate Student Affairs Office in the Department to plan for completion of this requirement.

In preparation for the Ph.D. Candidacy Examination, students must have completed the Departmental Comprehensive Examination and the Departmental Teaching Experience requirement, have 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 Regulation 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. Upon successful completion of this examination, students are advanced to candidacy and are awarded the Candidate in the Doctor 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 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 approximately 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 may not 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 are required to evaluate their 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 member may determine that the student cannot continue in the graduate program.

FOCUS AREAS FOR Ph.D. STUDENTS

(Please check class schedule for quarterly offerings)

Structural Analysis (take any 3)

SE 201A Advanced Structural Analysis
SE 201B Nonlinear Structural Analysis
SE 202 Structural Stability
SE 203 Structural Dynamics
SE 204 Advanced Structural Dynamics
SE 206 Random Vibrations
SE 205 Nonlinear Mechanical Vibrations
SE 215 Cable Structures
SE 224 Structural Reliability and Risk Analysis
SE 233 Computational Techniques in Finite Elements

Computational Mechanics and Finite Elements (take any 3)

SE 233 Computational Techniques in Finite Elements
SE 274 Nonlinear Finite Element Methods
SE 276A Finite Element Methods in Solid Mechanics I
SE 276B Finite Element Methods in Solid Mechanics II
SE 276C Finite Element Methods in Solid Mechanics III
SE 277 Error Control in Finite Element Analysis
SE 278A Computational Fluid Dynamics
SE 278B Computational Fluid-Structure Interaction
SE 279 Meshfree Methods for Linear and Nonlinear Mechanics

Structural Design (take any 3)

SE 151B Design of Prestressed Concrete
SE 211 Advanced Reinforced & Prestressed Concrete Design
SE 212 Advanced Structural Steel Design
SE 213 Bridge Design
SE 214 Masonry Structures
SE 220 Seismic Isolation and Energy Dissipation
SE 223 Advanced Seismic Design of Structures
SE 224 Structural Reliability and Risk Analysis

Earthquake Engineering (take any 3)

SE 203 Structural Dynamics
SE 206 Random Vibrations
SE 220 Seismic Isolation and Energy Dissipation
SE 221 Earthquake Engineering
SE 222 Geotechnical Earthquake Engineering

SE 223 Advanced Seismic Design of Structures
SE 243 Soil-structure Interaction

Advanced Composites (take any 3)

SE 251A Processing Science of Composites
SE 251B Mechanical Behaviors of Polymers & Composites
SE 252 Experimental Mechanics and NDE
SE 253A Mechanics of Laminated Comp. Structures I
SE 253B Mechanics of Laminated Comp. Structures II
SE 253C Mechanics of Laminated Anisotropy Plates & Shells
SE 260A Aerospace Structural Mechanics I
SE 260B Aerospace Structural Mechanics II
SE 262 Aerospace Structures Repair

Geotechnical Engineering (take any 3)

SE 222 Geotechnical Earthquake Engineering
SE 241 Advanced Soil Mechanics
SE 242 Advanced Foundation Engineering
SE 243 Soil-structure Interaction
SE 244 Numerical Methods in Geomechanics
SE 247 Ground Improvement
SE 250 Stability of Earth Slopes & Retaining Walls

Solid Mechanics (take any 3)

SE 234 Plates and Shells (or MAE equivalent)
SE 235. Wave Propagation in Elastic Media
SE 252. Experimental Mechanics and NDE
SE 271 Solid Mechanics for Structural & Aerospace Engineering
SE 272 Theory of Elasticity
SE 273 Inelasticity

Advanced Structural Behavior (take any 3)

SE 202 Structural Stability
SE 204 Advanced Structural Dynamics
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
SE 268 Structural System Testing and Model Correlation

SAMPLE NON-SE FOCUS AREAS FOR Ph.D. STUDENTS

(Please check class schedule for quarterly offerings)

Seismology (take any 3)

SIO 225 Physics of Earth Materials
SIO 227A Introduction to Seismology
SIO 227C Advanced Seismology II

Controls

MAE 280A Linear Systems Theory or ECE 275A Parameter Estimation
MAE 280B Linear Control Design or ECE 275B Parameter Estimation II
MAE 284 Robust and Multi-Variable Control

Computer-Aided Design

MAE 291 Design and Mechanics in Computer Technology
MAE 292 Computer-Aided Design and Analysis
MAE 293 Advanced Computer Graphics for Engineers and Scientists

Signal Processing (take any 3)

ECE 161A Introduction to Digital Signal Processing
ECE 251A Digital Signal Processing I
ECE 251B Digital Signal Processing II
ECE 251C Filter Banks and Wavelets
ECE 251D Array Processing
ECE 254 Detection Theories

Mathematics (take any 3)

MAE 290A, B Efficient Numerical Methods for Simulation, Optimization and Control
(Choose a third from MAE 232A, MAE 294A, or consent of advisor)
MAE 294A Introduction to Applied Mathematics
MAE 294B Introduction to Applied Mathematics II
MAE 294C Introduction to Applied Mathematics III

Material Science (take any 3)

MATS 211A Mechanical Properties
MAE 233A Fracture Mechanics
MAE 233B Micromechanics

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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. *Prerequisites: grade of C– or better in SE 151A.*

SE 200. Applied Mathematics in Structural Engineering (4)

This course is designed to give beginning students the basic preparation in mathematical methods required for graduate Structural Engineering courses. Topics include: linear algebra; systems of ordinary differential equations; diffusion and wave propagation problems; integral transforms; and calculus of variations. ***Prerequisites:*** graduate standing or approval of instructor.

SE 201A. Advanced Structural Analysis (4)

Application of advanced analytical concepts to structural engineering problems. Analysis of frame structures using matrix methods and introduction to the finite element method. Displacement-based and force-based beam element formulations. Development of computer programs for structural analysis. Use of computer resources. ***Prerequisites:*** graduate standing.

SE 201B. Nonlinear Structural Analysis (4)

The course emphasizes the principles behind modern nonlinear structural analysis software. It deals with the theory, computer implementation, and applications of methods of material and geometric nonlinear analysis. Emphasis is on 2D and 3D frame structures modeled using 1D (beam-column) elements. Use of computer resources. ***Prerequisites:*** SE 201A 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. Recommended preparation: SE 101A-C and SE 110A or equivalent background in solid mechanics and structural dynamics. ***Prerequisites:*** graduate standing.

SE 203. Structural Dynamics (4)

Response of discrete linear structural systems to harmonic, periodic and transient excitations. Lagrangian mechanics. Linearization of the equations of motion. Free and forced vibrations of multi degree-of-freedom structures. Normal mode, frequency response and numerical methods. Continuous systems. ***Prerequisites:*** graduate standing or consent of instructor.

SE 204. Advanced Structural Dynamics (4)

Free-and forced-vibration of continuous systems such as axial and torsional vibrations of bars and transverse vibrations of various beams, membranes, and plates. Euler-Lagrange formulation using variational calculus. Rayleigh-Ritz method for approximation. Applications in vibration suppression/isolation. ***Prerequisites:*** 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. ***Prerequisites:*** SE 203 or consent of instructor; graduate standing.

SE 206. Random Vibrations (4)
Introduction to probability theory and random processes. Dynamic analysis of linear 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. Use of computer resources. Recommended preparation: basic knowledge of probability theory (SE 125 or equivalent). ***Prerequisites:*** SE 203; graduate standing.

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 Structural Concrete (4)
Properties of reinforcing steels; concrete technology; creep, shrinkage and relaxation; Mohr-Coulomb failure criteria for concrete; confinement, momentcurvature and force-displacement responses; plastic design; code compliant seismic design philosophy; code compliant seismic design of structural walls. Use of computer resources. Recommended preparation: SE 151A and SE 151B or equivalent background in basic RC/PC design. ***Prerequisites:*** department approval 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. Load paths and distribution of dead and live loads. Service, strength, and extreme event limit states and other load and resistance factor design (LRFD) principles. Design of pre-stressed concrete bridges. Special problems in analysis—concrete box girders, curved and skewed bridges, environmental and seismic loads. Conceptual/preliminary bridge design project. Recommended preparation: SE

223 (Advanced Seismic Design of Structures). ***Prerequisites:*** SE 201A and SE 211, graduate standing.

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. ***Prerequisites:***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. ***Prerequisites:*** 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. Use of computer resources. ***Prerequisites:*** SE 203 or consent of instructor; graduate standing.

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. Recommended preparation: SE 181 or equivalent. ***Prerequisites:*** department approval and graduate standing.

SE 223. Advanced Seismic Design of Structures (4)
Modal analysis. Nonlinear response spectra. Performance based seismic design. Nonlinear time history analyses. Capacity design. Structural walls. Coupled walls. Rocking walls. Base isolation. Recommended preparation: grade of B+ or higher in SE 211 and SE 201B. ***Prerequisites:***department approval and graduate standing.

SE 224. Structural Reliability and Risk Analysis (4)
Review of probability theory and random processes. Fundamentals of structural reliability theory. First- and second-order, and simulation methods of reliability analysis. Structural

component and system reliability. Reliability sensitivity measures. Bayesian reliability analysis methods. Bases for probabilistic design codes. Use of computer resources. Recommended preparation: basic knowledge of probability theory (e.g., SE 125). ***Prerequisites:*** graduate standing.

SE 226. Geotechnical Groundwater Engineering (4)
This course will treat quantitative aspects of the flow of uncontaminated groundwater as it influences the practice of geotechnical engineering. We will cover flow through porous media, generalized Darcy's law, groundwater modeling, confined and unconfined systems, well hydraulics, land subsidence, and construction dewatering. ***Prerequisites:*** SE 241 or consent of instructor.

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 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 nondestructive evaluations. ***Prerequisites:*** 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. ***Prerequisites:*** 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. 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 and effects on structural design. Analysis of axial and lateral capacity of deep foundations, including drilled piers and driven piles. ***Prerequisites:*** graduate standing or consent of instructor.

SE 243. Soil-Structure Interaction (4)
Advanced treatment of the dynamic interaction between soils and structures. Dynamic response of shallow and embedded foundations. Kinematic and inertial interaction. General computational

and approximate analytical methods of analysis. ***Prerequisites:*** SE 200 and SE 203; graduate standing.

SE 244. Numerical Methods in Geomechanics (4)
Application of finite element method to static and dynamic analysis of geotechnical structures. One-, 2-, and 3-D static and seismic response of earth structures/slopes/Foundation systems. Pore-pressure generation/effects during cycle loading. System identification using strong motion downhole-array data. Use of computer resources required. ***Prerequisites:*** graduate standing.

SE 247. Ground Improvement (4)
Concepts underpinning mechanical, hydraulic, chemical and inclusion-based methods of ground improvement will be discussed. Students will be able to understand the advantages, disadvantages and limitations of the various methods; and develop a conceptual design for the most appropriate improvement strategy. Recommended Preparation: SE 181 or equivalent background in the physics and engineering properties of soil. ***Prerequisites:*** graduate standing.

SE 248. Engineering Properties of Soils (4)
Experimental/constitutive modeling perspectives on mechanical, hydraulic, thermal behavior of dry and saturated soils. Experimental techniques and methodologies presented; students will be able to perform key tests. Behavior of saturated sands and clays described based on key studies. Calibration of constitutive models for stress-strain behavior of soils, including hyperbolic, Mohr-Coulomb/Cam-Clay models. Modification of these models to consider thermal effects. ***Prerequisites:*** graduate standing.

SE 250. Stability of Earth Slopes and Retaining Walls (4)
Fundamental and advanced concepts of stability analysis for earth slopes and retaining walls with soil backfill. Topics: shear strength, effective/total stress analysis, infinite/finite slopes, reinforced soil slopes, lateral earth pressure, retaining wall design and reinforced soil retaining walls. Recommended preparation: SE 181 or equivalent background. ***Prerequisites:*** department approval and graduate standing.

SE 251A. Processing of Polymers and Composites (4)
Introduction to processing and fabrication methods of polymers and composite materials. Processing techniques; facilities and equipment; material-processing-microstructure interaction; materials selection; form and quality control. Extrusion; injection molding; blow molding; compression molding; thermoforming; casting; foaming. Wet layup; sprayup; autoclave cure, SMC; RTM; resin infusion; winding and fiber placement; pultrusion. Process induced defects and environmental considerations. Cross-listed with MATS 261A. ***Prerequisites:*** 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. Cross-listed with MATS 261B. ***Prerequisites:*** graduate standing required.

SE 252. Experimental Mechanics and NDE (4)
Requirements for strain measurements, electrical resistance strain gages, fiberoptic strain gages, wave propagation, ultrasonic testing, impact-echo, acoustic emission, infrared thermography, vibrational testing. Applications to materials characterization, defect detection, and health monitoring of structural components. Recommended preparation: SE 101A, SE 110A or MAE 131A, and SE 110B or MAE 131B. ***Prerequisites:*** department approval required, graduate standing.

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. ***Prerequisites:*** 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/elastic stability of laminated anisotropic plates and cylindrical shells. Theories: thin-plate (classical lamination theory), first-and third- order shear-deformable (Reissner-Mindlin and Reddy) thick plates, and refined layer-wise theories. Solution methods: exact, approximate (Ritz, Galerkin) and finite element method. Additional topics: sandwich construction, elastic couplings, theormal response, shear factor determination, fiber/interlaminar stress recovery, strength/safety. ***Prerequisites:*** SE 253B; graduate standing 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. Use of computer resources. ***Prerequisites:*** SE 253A; graduate standing.

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 260A. Aerospace Structural Mechanics I (4)

Aircraft and spacecraft flight loads and operational envelopes, three-dimensional stress/strain relations, metallic and composite materials, failure theories, three-dimensional space trusses and stiffened shear panels, combined extension-bend-twist behavior of thin-walled multicell aircraft and space vehicle structures, modulus-weighted section properties, shear center. ***Prerequisites:***graduate standing.

SE 260B. Aerospace Structural Mechanics II (4)
Analysis of aerospace structures via work-energy principles and finite element analysis. Bending of metallic and laminated composite plates and shells. Static vibration, and buckling analysis of simple and built-up aircraft structures. Introduction to wing divergence and flutter, fastener analysis. ***Prerequisites:*** SE 260A; graduate standing.

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)
Review methods used to repair aerospace structures. Emphasis on primary load-bearing airframe structures and analysis/design of substantiate repairs. Identification of structural/corrosion distress, fatigue cracking, damage tolerance, integrity and durability of built-up members, patching, health monitoring. Use of computer resources. ***Prerequisites:*** department approval required, graduate standing.

SE 263. Non-Destructive Evaluation (4)
Fourier signal processing, liquid penetrant, elastic wave propagation, ultrasonic testing, impact-echo, acoustic emission testing, vibrational testing, infrared thermography.

SE 264. Sensors and Data Acquisition for Structural Engineering (4)
This course discusses theory, design and applications of sensor technologies in the context of structural engineering and structural health monitoring. Topics include: sensors and sensing mechanisms; measurement uncertainty; signal conditioning and interface circuits; data acquisition; analog/digital circuits; and emerging sensors.

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 266. Smart and Multifunctional Materials (4)
This course examines the properties, physics, mechanisms, and design of smart and multifunctional materials; data acquisition and operating principles of sensor technologies; smart materials (piezoresistive, piezoelectric, magnetorheological, and shape memory materials);

nanotechnology-enabled multifunctional materials; and applications for structural health monitoring. Use of computer resources. ***Prerequisites:*** graduate standing.

SE 268. 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. Recommended preparation: vibrations, finite element analysis, and knowledge of Matlab. ***Prerequisites:*** graduate standing or consent of instructor.

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. Inelasticity (4)
Overview of inelastic behavior of materials. Models of plasticity, viscoplasticity, viscoelasticity. Micromechanics and modeling of damage. Fatigue phenomena. Fracture mechanics. Processes and models of the failure of materials. Students may not receive credit for SE 273 and MAE 231C. ***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 3-D solids and rods, beams, shells: elasticity, plasticity, viscoplasticity. ***Prerequisites:*** 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. ***Prerequisites:*** SE 232B or MAE 232B.

SE 278A. Finite Elements for Fluid Mechanics (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. ***Prerequisites:*** MAE 232A or SE 276A or consent of instructor; graduate standing.

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. ***Prerequisites:*** SE 278A.

SE 279. Meshfree Methods for Linear and Nonlinear Mechanics (4)
Meshfree approximation theories (moving least-squares, reproducing kernel, partition of unity, radial basis), Galerkin meshfree methods, collocation meshfree methods, imposition of boundary conditions, domain integration, stability, nonlinear meshfree method for hyperelasticity and plasticity, meshfree methods for fracture and plate/shell problems. ***Prerequisites:*** SE 276A or MAE 232A; graduate standing.

SE 280. Finite Element Computations in Solid Mechanics (4)
Techniques of computation with the finite element method. Preprocessing (geometry, mesh generation, boundary conditions), solution methods (statics including contact, dynamics, buckling), and postprocessing (visualization, error estimation, interpretation of results). Hands-on exercises with commercial and open-source software. Use of computer resources. ***Prerequisites:*** graduate standing, SE 276A or MAE 232A, and SE 276B or MAE 232B.

SE 285. Structural Optimization (4)

Construction of structural design as an optimization problem; mathematical programming for sizing, shape and topology; linear and nonlinear programming; continuous and discrete optimization methods; Lagrangian function and KKT optimality condition; MATLAB. ***Prerequisites:*** graduate standing, SE 276A or MAE 232A or SE 233 or MAE 235.

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)
Prerequisites: 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.)

THE CAMPUS

UCSD is situated on a park-like 1,200-acre site high on the bluffs over-looking the Pacific Ocean in La Jolla. La Jolla boasts some of the finest beaches and coves, restaurants, art galleries, and other attractions in the nation. The San Diego metropolitan area - which includes the UCSD campus - enjoys one of the most comfortable climates in the United States, twelve months out of the year.

Much of UCSD's recreational and social life centers on the waterfront, with surfing, scuba diving and other such activities. Mission Bay Park and San Diego Bay beaches are a favorite playground of San Diegans. Mission Bay is a great place for sailing, jet skiing and wind surfing. Throughout the area, students find a variety of amusements, ranging from the small-town atmosphere of waterfront Del Mar southward to the open-air markets of Tijuana and the rustic wilderness of Mexico's Baja California Peninsula.

The city of San Diego is 12 miles south of the campus, and offers a wide range of recreational opportunities, including Old Town (California's birthplace), Sea World in Mission Bay, and the world-famous San Diego Zoo and Safari Park. A year-round calendar of major league sporting events is offered in the city's Sports Arena, Petco Park, home of the Padres, and Qualcomm Stadium, the home of the Chargers.

For theater lovers, there are numerous stages in San Diego, including the Old Globe Theater in Balboa Park-- the site of the National Shakespeare Festival every summer. A year-round program of contemporary and classical professional theater may be enjoyed in the Old Globe and the adjacent and special summer theater fare is featured on the park's outdoor Festival Stage. We also have the La Jolla Playhouse, a professional theatre located on the UCSD campus. The Playhouse is where you can see classic productions, new plays and spectacular musicals. The Department of Theater presents plays in both the 500-seat Mandell Weiss Center of the Performing Arts. The Department of Visual Arts also offers a continuing series of art shows in the University Art Gallery, and displays of student art in other campus galleries.

Fishing opportunities are plentiful offshore in kelp beds west of La Jolla, and surrounding the Coronado Islands in Mexican waters. Bass and trout fishing are available in nearby lakes. An

hour’s drive to the east, the Laguna Mountains provide pleasure in all seasons for campers and hikers. Beyond the Laguna’s lies the vast Anza-Borrego Desert with its breathtaking display of wild flowers in the spring.

The peninsula of Baja California, one of the world’s last great wilderness areas, stretches 900 miles southward from the international gateway at Tijuana. The peninsula - a mecca for lovers of unsoiled beaches and untouched mountains and deserts - is the site every year of the grueling Baja cross-country auto race.

RESEARCH FACILITIES

The high national and international visibility and recognition of the UCSD Structural Engineering program can be attributed to the outstanding and unique experimental facilities and the high quality of the structural engineering faculty.

The Charles Lee Powell Structural Research Laboratories have developed over the past two decades into one of the world's leading experimental structural research facilities for large and full-scale testing of structural systems and components. Currently, three separate test facilities comprise the Powell Structural Research Laboratories on UCSD campus. **The Structural Systems Laboratory** with a 15-m high reaction wall and a 30-m long and 15-m wide strong floor is capable of full-scale testing of up to 5-story buildings under simulated seismic loads and complete bridge systems under simulated traffic and/or seismic load conditions. **The Structural Components Laboratory** features a 20-m long reaction wall for structural component tests such as columns, beams, joints, etc., and a 5 x 3-m shake table for real time earthquake load simulation on structural models and components with payloads close to 40 tons. The third testing facility, **Composite and Aerospace Structures Laboratory,** is dedicated to the evaluation of advanced composite structural components and systems.

State-of-the-art equipment including servo-controlled hydraulic actuators and signal conditioning for up to 1,500 high-speed data channels provides structural testing capabilities which are unequaled worldwide.

The Powell Structural Research Laboratories also include manufacturing and materials characterization laboratories, such as the **Advanced Composites Laboratory** for advanced composite materials and structural members, and geotechnical research laboratories with a state-of-the-art geotechnical centrifuge (5 meter diameter). A fourth large-scale structural testing laboratory houses the **Caltrans Seismic Response Modification Device (SRMD) Testing Facility** for the full-scale testing and evaluation of seismic response mitigation devices such as base-isolation bearings and dampers.

With its one-of-a-kind facilities, the **Englekirk Structural Engineering Center** at the Elliot Field Station of the University of California, San Diego is enabling structural tests that have never been possible before. The Center is equipped with the world's first outdoor shake table (http://nees.ucsd.edu), as part of the Network for Earthquake Engineering Simulation supported by NSF, allowing researchers to perform dynamic earthquake safety tests on full-scale structural systems. Adjacent to it is the country's largest soil-structure interaction test facility.. The Center's **blast simulator** is being used to study the effects of bomb blasts and test new technologies to harden buildings against terrorist bomb attacks.

Other research laboratories include the **NDE & Structural Health Monitoring Laboratory** and **Structural Dynamics Laboratory**. Laboratory listings and additional information can be found on our web site (http://structures.ucsd.edu/node/53).

ACADEMIC CALENDAR 2017-18

Fall 2017	
Fall Quarter begins	Monday, September 25
Instruction begins	Thursday, September 28
Veterans Day Holiday	Friday, November 10
Thanksgiving Holiday	Thursday – Friday, November 23–24
Instruction ends	Friday, December 8
Final Exams	Saturday – Saturday, December 9–16
Fall Quarter ends	Saturday, December 16
Winter Break	Monday – Tuesday, December 25–26
New Year Holiday	Monday – Tuesday, January 1– 2
- 49 Days of Instruction -	
- 60 Days in Quarter -	
Winter 2018	
Winter Quarter begins	Wednesday, January 3
Instruction begins	Monday, January 8
Martin Luther King, Jr. Holiday	Monday, January 15
Presidents' Day Holiday	Monday, February 19
Instruction ends	Friday, March 16
Final Exams	Saturday – Saturday, March 17–24
Winter Quarter ends	Saturday, March 24
- 48 Days of Instruction -	
- 58 Days in Quarter -	
Spring 2018	
Spring Quarter begins	Wednesday, March 28
César Chávez Holiday	Friday, March 30
Instruction begins	Monday, April 2
Memorial Day observance	Monday, May 28
Instruction ends	Friday, June 8
Final Exams	Saturday – Friday, June 9–15
Spring Quarter ends	Friday, June 15
Commencement programs	Saturday – Sunday, June 16–17
- 49 Days of Instruction -	
- 58 Days in Quarter -	

IMPORTANT NUMBERS – IN CASE OF AN EMERGENCY

EMERGENCY – Life threatening situation

• From a campus phone From a cell phone, call UCSD Campus Police	911 858-534-HELP (4357)
• If the emergency involves any of the department labs Notify Noah Aldrich, the Department Safety Officer	858-534-4302 (cell) (619) 415-9226
• UCSD Medical Center, La Jolla, Thornton Hospital, Emergency and Urgent Care	858-657-7600
• UCSD Medical Center, Hillcrest Emergency and Urgent Care	(619) 543-6400
• Student Health Services (Urgent Care)	858-534-3300
• San Diego County Center for Community Solutions (Rape Crisis Hotline)	(888) 385-4657
• Student Sexual Assault Resource Center (SARC)	858-534-5793
• Counseling and Psychological Services (CAPS)	858-534-3755
• Poison Information Hotline (24 hour)	858-876-4766
• Environment Health & Safety Hotline	858-534-3660
• Physical Plant Repair (Trouble Desk) Facilities Management	858-534-2930

Additional Resources:

• Lost & Found	858-534-4361
• Student Policies & Judicial Affairs (SPJA)	858-534-6225
• Office for Students with Disabilities (OSD)	858-534-4382
• International Center	858-534-3730

DIRECTORY OF CAMPUS SERVICES

Resources:

- Academic Computing Services acs-help@ucsd.edu
- Bookstore http://ucsandiegobookstore.com/
- Graduate Student Association (GSA) gsa@ucsd.edu
- Office of Graduate Studies (OGS) http://ogs.ucsd.edu/
- UCSD Libraries http://libraries.ucsd.edu/
- Parking parking@ucsd.edu
- Photo I.D./Campus I.D. Card 858-534-4322 campuscards@ucsd.edu
- Registrar Office 858-534-3150 http://registrar.ucsd.edu
- Residency Requirements 858-534-4586
  http://registrar.ucsd.edu/residency
- Student Financial Aid http://fao.ucsd.edu
- Student Health Services http://studenthealth.ucsd.edu
- Student Information - (EDNA) Price Center 858-534-EDNA (3362)

Campus Services:

- Career Service 858-534-3750 http://career.ucsd.edu
- Center for Teaching Development (CTD) 858-534-6767 www.ctd.ucsd.edu
- Cross Cultural Center 858-534-9689 http://ccc.ucsd.edu/
- International Center 858-534-3730 http://icenter.ucsd.edu/
- Lesbian, Gay, Bisexual, Transgender Resource 858-822-3493 http://lgbt.ucsd.edu/
- Office for Student with Disabilities (OSD) 858-534-4382
  http://disabilities.ucsd.edu/
- Psychological and Counseling Services 858-534-3755
  http://psychservices.ucsd.edu/#graduate
- Sexual Harassment Prevention & Policy 858-534-8298
  http://students.ucsd.edu/well-being/_organizations/sarc/index.html
- Student Legal Services 858-534-4374
  http://students.ucsd.edu/campus-services/_organizations/student-legal/
- Student Safety and Awareness Program 858-534-5793
  http://students.ucsd.edu/well-being/_organizations/sarc/index.html
- Women's Center 858-822-0074 http://women.ucsd.edu/
- University Center Sunshine Store 858-534-2875

Child Care Services:

- Early Childhood Education Center 858-552-2500

***Recreation*:**

- Canyon View Pool http://recreation.ucsd.edu/
- Sports Facilities http://sportsfac.ucsd.edu/
- RIMAC 858-534-7884