MECHANICAL ENGINEERING

Courses offered by the Department of Mechanical Engineering are listed under the subject code ME on the *Stanford Bulletin's* ExploreCourses web site.

The programs in the Department of Mechanical Engineering (ME) emphasize a mix of applied mechanics, biomechanical engineering, computer simulations, design, and energy science and technology. Since mechanical engineering is a broad discipline, the undergraduate program can be a springboard for graduate study in business, law, medicine, political science, and other professions where understanding technology is important. Both undergraduate and graduate programs provide technical background for work in biomechanical engineering, environmental pollution control, ocean engineering, transportation, and other multidisciplinary problems that concern society. In all programs, emphasis is placed on developing systematic procedures for analysis, communication of work and ideas, practical and aesthetic aspects in design, and responsible use of technology.

Mission of the Undergraduate Program in Mechanical Engineering

The mission of the undergraduate program in Mechanical Engineering is to provide students with a balance of intellectual and practical experiences that enable them to address a variety of societal needs. The curriculum encompasses elements from a wide array of disciplines built around the themes of biomedicine, computational engineering, design, energy, and multiscale engineering. Course work may include mechatronics, computational simulation, solid and fluid dynamics, microelectromechanical systems, biomechanical engineering, energy science and technology, propulsion, sensing and control, nano- and micro-mechanics, and design. The program prepares students for entry-level work as mechanical engineers and for graduate studies in either an engineering discipline or another field where a broad engineering background is useful.

Learning Objectives (Undergraduate)

These outcomes are operationalized through learning objectives, which students are expected to demonstrate:

1. Graduates of the program will have the scientific and technical background for successful careers in diverse organizations.
2. Graduates of the program will be leaders, and effective communicators, both in the profession and in the community.
3. Graduates of the program will be motivated and equipped to successfully pursue postgraduate study whether in engineering, or in other fields.
4. Graduates of the program will have a professional and ethical approach to their careers with a strong awareness of the social contexts in which they work.

Learning Outcomes (Graduate)

The purpose of the master's program is to provide students with the knowledge and skills necessary for a professional career or doctoral studies. This is done through course work providing depth in one area of specialization and breadth in complementary areas. Areas of specialization range from automatic controls, energy systems, fluid mechanics, heat transfer, and solid mechanics to biomechanical engineering, MEMS, and design.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research. Through course work and guided research, the program prepares students to make original contributions in Mechanical Engineering and related fields.

Graduate Programs in Mechanical Engineering

Admission and Financial Assistance

Mechanical engineering is a varied profession, ranging from primarily aesthetic aspects of design to highly technical scientific research. Disciplinary areas of interest to mechanical engineers include biomechanics, energy conversion, fluid mechanics, materials, nuclear reactor engineering, propulsion, rigid and elastic body mechanics, systems engineering, scientific computing, thermodynamics, robotics, and controls, to name a few. Our graduate programs provide advanced depth and breadth in the field.

Graduate degree programs and admission

- Master of Science (M.S.) in Mechanical Engineering
- Master of Science (M.S.) in Engineering — Design Impact
- Doctor of Philosophy (Ph.D.) in Mechanical Engineering

To be eligible for admission to graduate study to the department, a student must have a B.S. degree in engineering, physics, or a comparable science program. M.S. and Ph.D. applications must be received by the first Tuesday in December, and admitted students must matriculate in the following Autumn. In rare circumstances, with the support of an ME faculty member who is a potential Ph.D. adviser, Ph.D. applications from students who have completed or are currently in an M.S. program are reviewed for Winter or Spring Quarter start. In addition, M.S. applicants eligible for the Honors Cooperative Program (on-campus courses required for Mechanical Engineering) can apply in Autumn, Winter, or Spring quarters.

Additional degree programs available to currently enrolled students

- Master of Science (M.S.) in Engineering — Biomechanical Engineering
- Master of Science (M.S.) in Engineering — Individually Designed Major
- Engineer in Mechanical Engineering

For additional information about these programs, see the Mechanical Engineering Department Graduate Handbook.

Financial Assistance

The department annually awards, on a competitive basis, a limited number of fellowships, teaching assistantships, and research assistantships to incoming graduate students. For M.S. students, limited financial aid in the form of fellowships and short-term research assistantships are provided at the time of admission, and course assistantships can sometimes be arranged with individual course instructors after admission. All Ph.D. students receive financial support for the duration of their program, given satisfactory degree progress.

Post-Master's Degree Programs

The department offers two post-master's degrees: Engineer and Doctor of Philosophy. Post-master's research generally requires some evidence that a student has research potential before a faculty member agrees to supervision and a research assistantship appointment. It is most efficient to carry out preliminary research during the M.S. degree program, if interested in a post-master's degree.

Departmental Groups

The department has five groups: Biomechanical Engineering; Design; Flow Physics and Computation; Mechanics and Computation; and Thermosciences. Each maintains its own labs, shops, and offices.

The Biomechanical Engineering (BME) Group has teaching and research activities which focus primarily on musculoskeletal biomechanics, neuromuscular biomechanics, cardiovascular biomechanics, and rehabilitation engineering. Research in other areas including hearing, ocean, plant, and vision biomechanics exists in collaboration with associated faculty in biology, engineering, and medicine. The group has strong research interactions with the Mechanics and Computation and the Design groups, and the departments of Neurology, Radiology, and Surgery in the School of Medicine.

The Design Group is devoted to the imaginative application of science, technology, and art to the conception, visualization, creation, analysis and realization of useful devices, products, and objects. Courses and research focus on topics such as kinematics, applied finite elements, microprocessors, medical devices, fatigue and fracture mechanics, dynamics and simulation, micro-electromechnical systems (MEMS), rehabilitation, optimization, high-speed devices, product design, vehicle dynamics, experimental mechanics, robotics, creativity, idea visualization, computer-aided design, manufacturing, design analysis, and engineering education.

The Flow Physics and Computational Engineering Group (FPCE) The Flow Physics and Computational Engineering Group (FPCE) blends research on flow physics and modeling with algorithm development, scientific computing, and numerical database construction. FPCE is contributing new theories, models and computational tools for accurate engineering design analysis and control of complex flows (including multi phase flows, micro-fluidics, chemical reactions, acoustics, plasmas, interactions with electromagnetic waves and other phenomena) in aerodynamics, propulsion and power systems, materials processing, electronics cooling, environmental engineering, and other areas. A significant emphasis of research is on modeling and analysis of physical phenomena in engineering systems.

The Mechanics and Computational Group covers biomechanics, continuum mechanics, dynamics, experimental and computational mechanics, finite element analysis, fluid dynamics, fracture mechanics, micromechanics, nanotechnology, and simulation based design. Qualified students can work as research project assistants, engaging in thesis research in association with the faculty director and fellow students. Projects include analysis, synthesis, and control of systems; biomechanics; flow dynamics of liquids and gases; fracture and micro-mechanics, vibrations, and nonlinear dynamics; and original theoretical, computational, and experimental investigations in the strength and deformability of elastic and inelastic elements of machines and structures.

The Thermosciences Group conducts experimental and analytical research on both fundamental and applied topics in the general area of thermal and fluid systems. Research strengths include high Reynolds number flows, microfluidics, combustion and reacting flows, multiphase flow and combustion, plasma sciences, gas physics and chemistry, laser diagnostics, microscale heat transfer, convective heat transfer, and energy systems. Research motivation comes from applications including air-breathing and space propulsion, bioanalytical systems, pollution control, electronics fabrication and cooling, stationary and mobile energy systems, biomedical systems, and materials processing. Emphasis is on fundamental experiments leading towards advances in modeling, optimization, and control of complex systems.

Facilities

The department groups maintain modern laboratories that support undergraduate and graduate instruction and graduate research work.

The Structures and Composites Laboratory, a joint activity with the Department of Aeronautics and Astronautics, studies structures made of fiber-reinforced composite materials. Equipment for fabricating structural elements includes autoclave, filament winder, and presses. X-ray, ultrasound, and an electron microscope are available for nondestructive testing. The lab also has environmental chambers, a high speed impactor, and mechanical testers. Lab projects include designing composite structures, developing novel manufacturing processes, and evaluating environmental effects on composites.

Experimental facilities are available through the interdepartmental Structures and Solid Mechanics Research Laboratory, which includes an electrohydraulic materials testing system, a vehicle crash simulator, and a shake table for earthquake engineering and related studies, together with highly sophisticated auxiliary instrumentation. Facilities to study the micromechanics of fracture areas are available in the Micromechanics/Fracture Laboratory, and include a computer-controlled materials testing system, a long distance microscope, an atomic force microscope, and other instrumentation. Additional facilities for evaluation of materials are available through the Center for Materials Research, Center for Integrated Circuits, and the Ginzton Laboratory. Laboratories for biological experimentation are accessible through the School of Medicine. Individual accommodation is available for the work of each research student.

Major experimental and computational laboratories engaged in bioengineering work are located in the Biomechanical Engineering Group. Other Biomechanical Engineering Group activities and resources are associated with the Rehabilitation Research and Development Center of the Veterans Administration Palo Alto Health Care System. This major national research center has computational and prototyping facilities. In addition, the Rehabilitation Research and Development Center houses the Electrophysiology Laboratory, Experimental Mechanics Laboratory, Human Motor Control Laboratory, Rehabilitation Device Design Laboratory, and Skeletal Biomechanics Laboratory. These facilities support graduate course work as well as Ph.D. student research activities.

Computational and experimental work is also conducted in various facilities throughout the School of Engineering and the School of Medicine, particularly the Advanced Biomaterials Testing Laboratory of the Department of Materials Science and Engineering, the Orthopaedic Research Laboratory in the Department of Functional Restoration, and the Vascular Research Laboratory in the Department of Surgery. In collaboration with the School of Medicine, facilities throughout the Stanford Medical Center and the Veterans Administration Palo Alto Health Care System conduct biological and clinical work.

The Design Group has facilities for lab work in experimental mechanics and experimental stress analysis. Additional facilities, including MTS electrohydraulic materials test systems, are available in the Solid Mechanics Research Laboratory. Design Group students also have access to Center for Integrated Systems (CIS) and Ginzton Lab microfabrication facilities.

The group also maintains the Product Realization Laboratory (PRL), a teaching facility offering students integrated experiences in market definition, product design, and prototype manufacturing. The PRL provides coaching, design manufacturing tools, and networking opportunities to students interested in product development. The ME 310 Design Project Laboratory has facilities for CAD, assembly, and testing of original designs by master's students in the engineering design program. A Smart Product Design Laboratory supports microprocessor application projects. The Center for Design Research (CDR) has an excellent facility for concurrent engineering research, development, and engineering curriculum creation and assessment. Resources include a network of high-performance workstations. For worldwide web mediated concurrent engineering by virtual, non-collocated, design development teams, see the CDR web site at http://cdr.stanford.edu. In addition, CDR has several industrial robots for student projects and research. These and several NC machines are part of the CDR Manufacturing Sciences Lab. The Manufacturing Modeling Laboratory (MML) addresses various models and methods that lead to competitive manufacturing. MML links design for manufacturing (dfM) research at the Department of Mechanical Engineering with supply chain management activities at the Department of Management Science and Engineering. The Rapid Prototyping Laboratory consists of seven processing stations including cleaning, CNC milling, grit blasting, laser deposition, low temperature deposition, plasma deposition, and shot peening. Students gain experience by using ACIS and Pro Engineer on Hewlett Packard workstations for process software development. The Design Group also has a Product Design Loft in which students in the Joint Program in Design develop graduate thesis projects.

The Flow Physics and Computation Group has a 32 processor Origin 2000, 48-node and 85-node Linux cluster with high performance interconnection and an array of powerful workstations for graphics and data analysis. Several software packages are available, including all the major commercial CFD codes. FPC is strongly allied with the Center for Turbulence Research (CTR), a research consortium between Stanford and NASA, and the Center for Integrated Turbulence Simulations (CITS), which is supported by the Department of Energy (DOE) under its Accelerated Strategic Computing Initiative (ASCI). The Center for Turbulence Research has direct access to major national computing facilities located at the nearby NASA-Ames Research Center, including massively parallel super computers. The Center for Integrated Turbulence Simulations has access to DOE's vast supercomputer resources. The intellectual atmosphere of the Flow Physics and Computation Group is greatly enhanced by the interactions among CTR's and CITS's postdoctoral researchers and distinguished visiting scientists.

The Mechanics and Computation Group has a Computational Mechanics Laboratory that provides an integrated computational environment for research and research-related education in computational mechanics and scientific computing. The laboratory houses Silicon Graphics, Sun, and HP workstations and servers, including an 8-processor SGI Origin2000 and a 16-processor networked cluster of Intel-architecture workstations for parallel and distributed computing solutions of computationally intensive problems. Software is available on the laboratory machines, including commercial packages for engineering analysis, parametric geometry and meshing, and computational mathematics. The laboratory supports basic research in computational mechanics as well as the development of related applications such as simulation-based design technology.

The Thermosciences Group has four major laboratory facilities. The Heat Transfer and Turbulence Mechanics Laboratory concentrates on fundamental research aimed at understanding and improved prediction of turbulent flows and high performance energy conversion systems. The laboratory includes two general-purpose wind tunnels, a pressurized high Reynolds number tunnel, two supersonic cascade flow facilities, three specialized boundary layer wind tunnels, and several other flow facilities. Extensive diagnostic equipment is available, including multiple particle-image velocimetry and laser-Doppler anemometry systems.

The High Temperature Gas Dynamics Laboratory includes research on sensors, plasma sciences, cool and biomass combustion and gas pollutant formation, and reactive and non-reactive gas dynamics. Research facilities include diagnostic devices for combustion gases, a spray combustion facility, laboratory combustors including a coal combustion facility and supersonic combustion facilities, several advanced laser systems, a variety of plasma facilities, a pulsed detonation facility, and four shock tubes and tunnels. The Thermosciences Group and the Design Group share the Microscale Thermal and Mechanical Characterization laboratory (MTMC). MTMC is dedicated to the measurement of thermal and mechanical properties in thin-film systems, including microfabricated sensors and actuators and integrated circuits, and features a nanosecond scanning laser thermometry facility, a laser interferometer, a near-field optical microscope, and an atomic force microscope. The activities at MTMC are closely linked to those at the Heat Transfer Teaching Laboratory (HTTL), where undergraduate and master's students use high-resolution probe stations to study thermal phenomena in integrated circuits and thermally-actuated microvalves. HTTL also provides macroscopic experiments in convection and radiative exchange.

The Energy Systems Laboratory is a teaching and research facility dedicated to the study of energy conversion systems. The lab includes three dynamometers for engine testing, a computer-controlled variable engine valve controller, a fuel-cell experimental station, a small rocket testing facility, and a small jet engine thrust stand.

The Guidance and Control Laboratory, a joint activity of the Department of Aeronautics and Astronautics and the Department of Mechanical Engineering, specializes in construction of electromechanical systems and instrumentation, particularly where high precision is a factor. Work ranges from robotics for manufacturing to feedback control of fuel injection systems for automotive emission control. The faculty and staff work in close cooperation with both the Design and Thermosciences Groups on device development projects of mutual interest.

Many computation facilities are available to department students. Three of the department's labs are equipped with super-minicomputers. Numerous smaller minicomputers and microcomputers are used in the research and teaching laboratories.

Library facilities at Stanford beyond the general library include Engineering, Mathematics, and Physics department libraries.

Mechanical Engineering Course Catalog Numbering System

The department uses the following course numbering system:

Number	Level
001-099	Freshman and Sophomore
100-199	Junior and Senior
200-299	Advanced Undergraduate and Beginning Graduate
300-399	Graduate
400-499	Advanced Graduate
500	Ph.D. Thesis

Bachelor of Science in Mechanical Engineering

The mission of the undergraduate program in Mechanical Engineering is to provide students with a balance of theoretical and practical experiences that enable them to address a variety of societal needs, from more efficient engines and new forms of mobility, to greater access to medical and health services in developing countries. The curriculum encompasses elements from a wide range of disciplines built around the themes of computational engineering, design, energy, mechanics and dynamic systems, consistently considering these topics in their larger societal and professional context. Course work may include mechatronics, computational simulation, solid mechanics, fluid dynamics, electromechanical systems, biomechanical engineering, energy science and technology, sensing and control, and design. The Program prepares students for entry-level work as mechanical engineers and for graduate studies in either an engineering discipline or other fields where a broad engineering background is useful.

Grade Requirements

To be recommended by the department for a B.S. in Mechanical Engineering, a student must achieve the minimum grade point average (GPA) set by the School of Engineering (2.0 in engineering fundamentals and mechanical engineering depth).

Students interested in the minor should see the "Minor in Mechanical Engineering" section of this bulletin.

Mechanical Engineering (ME)

Completion of the undergraduate program in Mechanical Engineering leads to the conferral of the Bachelor of Science in Mechanical Engineering.

Mission of the Undergraduate Program in Mechanical Engineering

The mission of the undergraduate program in Mechanical Engineering is to provide students with a balance of theoretical and practical experiences that enable them to address a variety of societal needs. The curriculum encompasses elements from a wide range of disciplines built around the themes of biomedicine, computational engineering, design, energy, and multiscale engineering. Course work may include mechatronics, computational simulation, solid and fluid dynamics, microelectromechanical systems, biomechanical engineering, energy science and technology, propulsion, sensing and control, nano- and micro- mechanics, and design. The program prepares students for entry-level work as mechanical engineers and for graduate studies in either an engineering discipline or other fields where a broad engineering background is useful.

Core Requirements

		Units
Mathematics		
24 units minimum; see Basic Requirement 1 [1]		
CME 102/ENGR 155A	Ordinary Differential Equations for Engineers	5
or MATH 53	Ordinary Differential Equations with Linear Algebra	
Select one of the following:		3-5
CME 106/ ENGR 155C	Introduction to Probability and Statistics for Engineers	
STATS 110	Statistical Methods in Engineering and the Physical Sciences	
STATS 116	Theory of Probability	
Plus additional courses to total min. 24		
Science		
20 units minimum; see Basic Requirement 2 [1]		
CHEM 31X	Chemical Principles Accelerated	5
Plus addtional required courses [1]		
Technology in Society		
One course required; TIS courses should be selected from AA 252, BIOE 131, CS 181, ENGR 131 or ME 267		3-5
Engineering Fundamentals		
Two courses minimum; see Basic Requirement 3		
ENGR 14	Intro to Solid Mechanics	3
ENGR 70A	Programming Methodology (same as CS 106A)	5
Engineering Core		
Minimum of 68 Engineering Science and Design ABET units; see Basic Requirement 5		
ME 1	Introduction to Mechanical Engineering	3
ENGR 15	Dynamics	3
ME 80	Mechanics of Materials	3
ME 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	3
ME 131A	Heat Transfer	3
ME 102	Foundations of Product Realization	3
ME 103	Product Realization: Design and Making	3
ME 112	Mechanical Systems Design [2]	3
ME 123	Computational Engineering	4
ME 170A	Mechanical Engineering Design- Integrating Context with Engineering [3]	4
ME 170B	Mechanical Engineering Design: Integrating Context with Engineering [3]	4

Core Concentrations and Concentration Electives

In addition to completing core requirements, students must choose one of the concentrations paths below. In addition to their concentration specific 3-courses, students select 2-3 additional courses such that the combination adds up to a minimum of 18 units. One of these additional courses must be from technical electives associated with the student's selected concentration. The other 1-2 courses could come from either technical electives from the student's selected concentration or any other concentration and its associated technical electives.

		Units
Dynamic Systems and Controls Concentration		
ME 161	Dynamic Systems, Vibrations and Control	3
ENGR 105	Feedback Control Design	3
Pick one of:		
ME 227	Vehicle Dynamics and Control	3
ME 327	Design and Control of Haptic Systems	3
Dynamic Systems and Controls Electives		
ME 171E	Aerial Robot Design	4
ENGR 205	Introduction to Control Design Techniques	3
ME 210	Introduction to Mechatronics	4
ME 220	Introduction to Sensors	3-4
ME 331A	Advanced Dynamics & Computation	3
ME 485	Modeling and Simulation of Human Movement	3
Pick one, if not used in concentration already:		
ME 227	Vehicle Dynamics and Control	3
ME 327	Design and Control of Haptic Systems	3

		Units
Materials and Structures Concentration		
ME 149	Mechanical Measurements	3
ME 151	Introduction to Computational Mechanics	3
ME 152	Material Behaviors and Failure Prediction	3
Materials and Structures Electives		
ME 234	Introduction to Neuromechanics	3
ME 241	Mechanical Behavior of Nanomaterials	3
ME 281	Biomechanics of Movement	3
ME 283	Introduction to Biomechanics and Mechanobiology	3
ME 287	Mechanics of Biological Tissues	4
ME 331A	Advanced Dynamics & Computation	3
ME 335A	Finite Element Analysis	3
ME 338	Continuum Mechanics	3
ME 339	Introduction to parallel computing using MPI, openMP, and CUDA	3
ME 345	Fatigue Design and Analysis	3
ME 348	Experimental Stress Analysis	3

		Units
Product Realization Concentration		
ME 127	Design for Additive Manufacturing	3

ME 128	Computer-Aided Product Realization	3
ME 129	(offered AY 19-20)	
Product Realization Electives		
ENGR 110	Perspectives in Assistive Technology (ENGR 110)	3
ENGR 240	Introduction to Micro and Nano Electromechanical Systems	3
ME 181	Deliverables: A Mechanical Engineering Design Practicum	3
CME 106	Introduction to Probability and Statistics for Engineers	4
ME 210	Introduction to Mechatronics	4
ME 263	The Chair	3-4
or ME 298	Silversmithing and Design	
ME 309	Finite Element Analysis in Mechanical Design	3
ME 324	Precision Engineering	4

		Units
Thermo, Fluids, and Heat Transfer Concentration		
ME 132	Intermediate Thermodynamics	4
ME 133	Intermediate Fluid Mechanics	3
ME 149	Mechanical Measurements	3
Thermo, Fluids, and Heat Transfer Electives		
ME 250	Internal Combustion Engines	1-5
ME 257	Gas-Turbine Design Analysis	3
ME 351A	Fluid Mechanics	3
ME 351B	Fluid Mechanics	3
ME 352A	Radiative Heat Transfer	3
ME 352B	Fundamentals of Heat Conduction	3
ME 352C	Convective Heat Transfer	3
ME 362A	Physical Gas Dynamics	3
ME 370A	Energy Systems I: Thermodynamics	3
ME 370B	Energy Systems II: Modeling and Advanced Concepts	4
ME 371	Combustion Fundamentals	3
AA 283	Aircraft and Rocket Propulsion	3

1 Math and science must total 45 units.
- Math: 24 units required and must include a course in differential equations (CME 102 Ordinary Differential Equations for Engineers or MATH 53 Ordinary Differential Equations with Linear Algebra; one of these required) and calculus-based Statistics (CME 106 Introduction to Probability and Statistics for Engineers or STATS 110 Statistical Methods in Engineering and the Physical Sciences or STATS 116 is required.
- Science: 20 units minimum and requires courses in calculus-based Physics and Chemistry, with at least a full year (3 courses) in one or the other. CHEM 31A Chemical Principles I/CHEM 31B Chemical Principles II are considered one course because they cover the same material as CHEM 31X Chemical Principles Accelerated but at a slower pace. CHEM 31X Chemical Principles Accelerated is recommended.

2 ME 112 fulfills the WIM requirement.

3 ME 170A and ME 170B are a two quarter Capstone Design Sequence and must be taken in consecutive quarters.

4 A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.

5 ME 129 will be offered Winter Quarter of AY 2019-20. Product realization students should take one of their concentration electives, or ME 219, in AY 2018-19.

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu).

BSME 1.0 Student Notes

Those students (primarily juniors and seniors) who are completing BSME 1.0 from prior years should refer to bulletins from the academic year that corresponds with their program sheet.

The following exception will be made for BSME 1.0 students in the AY 2018-19 year:

- ME 131B or ME 133 may be taken to fulfill that course requirement

Honors Program in Mechanical Engineering

The Department of Mechanical Engineering offers a program leading to a B.S. in Mechanical Engineering with honors. This program offers a unique opportunity for qualified undergraduate engineering majors to conduct independent study and research at an advanced level with a faculty mentor.

Mechanical Engineering majors who have a grade point average (GPA) of 3.5 or higher in the major may apply for the honors program. Students who meet the eligibility requirement and wish to be considered for the honors program must submit a written application to the Mechanical Engineering student services office no later than the second week of Autumn Quarter in the senior year. The application to enter the program can be obtained from the ME student services office, and must contain a one-page statement describing the research topic and include an unofficial Stanford transcript. In addition, the application must be approved by a Mechanical Engineering faculty member who agrees to serve as the thesis adviser for the project. Thesis advisers must be members of Stanford's Academic Council.

In order to receive departmental honors, students admitted to the program must:

1. Maintain the 3.5 GPA required for admission to the honors program.
2. Submit a completed thesis draft to the adviser by the 3rd week of the quarter the they intend to confer. Further revisions and final endorsement by the adviser are to be finished by week 6, when two bound copies are to be submitted to the Mechanical Engineering student services office.
3. Present the thesis at the Mechanical Engineering Poster Session held in mid-April. If the poster session is not offered or the student does not confer in the spring, an alternative presentation will be approved on a case by case basis with advisor and UGCC chair approval.

Note: Students may not use work completed towards an honors degree to satisfy the B.S. in ME course requirements.

Mechanical Engineering (ME) Minor

The following courses fulfill the minor requirements:

		Units
General Minor *		
ENGR 14	Intro to Solid Mechanics	3
ENGR 15	Dynamics	3
ME 1	Introduction to Mechanical Engineering	3
ME 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	3
Plus two of the following:		
ME 80	Mechanics of Materials	3
ME 103	Product Realization: Design and Making	3

ME 131A	Heat Transfer	3
ME 161	Dynamic Systems, Vibrations and Control	3
Total Units: 21		
Thermosciences Minor **		
ENGR 14	Intro to Solid Mechanics	3
ME 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	3
ME 131A	Heat Transfer	3
ME 149	Mechanical Measurements	3
ME 132	Intermediate Thermodynamics	4
ME 133	Intermediate Fluid Mechanics (offered SPR 18-19; more information to come)	3
Total units: 22		
Mechanical Design Minor ***		
ENGR 14	Intro to Solid Mechanics	3
ENGR 15	Dynamics	3
ME 80	Mechanics of Materials	3
ME 1	Introduction to Mechanical Engineering	3
ME 102	Foundations of Product Realization	3
ME 103	Product Realization: Design and Making	3
ME 112	Mechanical Systems Design	3
Plus one of the following:		
ME 113	Mechanical Engineering Design	4
ME 210	Introduction to Mechatronics	4
ME 220	Introduction to Sensors	3-4
Total units: 24-25		

* This minor aims to expose students to the breadth of ME in terms of topics and analytic and design activities. Prerequisites: MATH 19 Calculus, MATH 20 Calculus, MATH 21 Calculus, and PHYSICS 41 Mechanics or PHYSICS 41E Mechanics, Concepts, Calculations, and Context.

** Prerequisites: MATH 19 Calculus, MATH 20 Calculus, MATH 21 Calculus , MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications (or CME 100 Vector Calculus for Engineers) and PHYSICS 41 Mechanics or PHYSICS 41E Mechanics, Concepts, Calculations, and Context.

*** This minor aims to expose students to design activities supported by analysis. Prerequisites: MATH 19 Calculus, MATH 20 Calculus, MATH 21 Calculus,PHYSICS 42 Classical Mechanics Laboratory, and PHYSICS 41 Mechanics or PHYSICS 41E Mechanics, Concepts, Calculations, and Context.

Coterminal Master of Science Program in Mechanical Engineering

Stanford undergraduates who wish to continue their studies for the master of science degree in the coterminal program must have earned a minimum of 120 units towards graduation. This includes allowable Advanced Placement (AP) and transfer credit. Applicants must submit the Coterminal Online Application (https://applyweb.com/stanterm) no later than the quarter prior to the expected completion of their undergraduate degree. This is normally Winter Quarter (mid January) prior to Spring Quarter graduation.

The application must provide evidence of potential for strong academic performance as a graduate student. The Mechanical Engineering department graduate admissions committee makes decisions on each application. Typically, a GPA of at least 3.5 in engineering, science, and math is expected. Applicants must have completed two of ME 80 Mechanics of Materials, ME 112 Mechanical Systems Design, ME 131A Heat Transfer, and ME 131B Fluid Mechanics: Compressible Flow and Turbomachinery, and must take the Graduate Record Examination (GRE) before action is taken on the application.

Coterminal information, applications deadlines, and forms can be obtained from the ME student services office.

University Coterminal Requirements

Coterminal master's degree candidates are expected to complete all master's degree requirements as described in this bulletin. University requirements for the coterminal master's degree are described in the "Coterminal Master's Program (http://exploredegrees.stanford.edu/cotermdegrees)" section. University requirements for the master's degree are described in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin.

After accepting admission to this coterminal master's degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master's degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master's program, courses taken three quarters prior to the first graduate quarter, or later, are eligible for consideration for transfer to the graduate career. No courses taken prior to the first quarter of the sophomore year may be used to meet master's degree requirements.

Course transfers are not possible after the bachelor's degree has been conferred.

The University requires that the graduate adviser be assigned in the student's first graduate quarter even though the undergraduate career may still be open. The University also requires that the Master's Degree Program Proposal be completed by the student and approved by the department by the end of the student's first graduate quarter.

Master of Science in Mechanical Engineering

The basic University requirements for the M.S. degree are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin.

The master's program consists of 45 units of course work taken at Stanford. No thesis is required, although many students become involved in research projects during the master's program, particularly to explore their interests in working towards a Ph.D. degree. Students whose undergraduate backgrounds are entirely devoid of some of the major subject disciplines of engineering (for example, applied mechanics, applied thermodynamics, fluid mechanics, ordinary differential equations) may need to take some undergraduate courses to fill obvious gaps and prepare themselves to take graduate courses in these areas. Such students may require more than three quarters to fulfill the master's degree requirements, as the makeup courses may only be used as unrestricted electives (see item 4 below) in the M.S. degree program. However, it is not the policy to require fulfillment of mechanical engineering B.S. degree requirements to obtain an M.S. degree.

Mechanical Engineering

The master's degree program requires 45 units of course work taken as a graduate student at Stanford. No thesis is required. However, students who want some research experience during the master's program may participate in research or independent study through ME 391 Engineering Problems.

Students are encouraged to refer to the most recent *Mechanical Engineering Graduate Student Handbook* provided by the student services office. The department's requirements for the M.S. in Mechanical Engineering are as follows:

1. *Mathematical Fundamentals:* two mathematics courses for a total of at least 6 units from the following list are required: ME 300A, 300B, 300C, 408; CME 302; EE 261, 263; ENGR 155C/CME106. Only MATH courses with catalog numbers greater than 200 and CME courses with catalog numbers greater than 200 will count towards the math requirement. However, courses must cover two different areas out of the following choices: partial differential equations, linear algebra, numerical analysis and statistics. This excludes programming classes such as CS 106A/B/X; CME 211, 212, 213, 214, 292. Those classes can counted towards the Approved Electives category. Student who are unsure about the fit of CME or MATH courses fit into one of the areas above should consult with their faculty advisor. Courses taken for the math requirement must be taken for a letter grade.
2. *Depth in Mechanical Engineering:* a set of graduate-level courses in Mechanical Engineering to provide depth in one area. The faculty have approved these sets as providing depth in specific areas as well as a significant component of applications of the material in the context of engineering synthesis. These sets are outlined in the *Mechanical Engineering Graduate Student Handbook*. Depth courses must be taken for a letter grade.
3. *Breadth in Mechanical Engineering:* two additional graduate level courses (outside the depth) from the depth/breadth charts listed in the *Mechanical Engineering Graduate Handbook*. Breadth courses must be taken for a letter grade.
4. *Sufficient Mechanical Engineering Course Work:* students must take a minimum of 24 units of course work in mechanical engineering topics. For the purposes of determining mechanical engineering topics, any course on approved lists for the mathematics, depth, and breadth requirements counts towards these units. In addition, any graduate-level course with an ME course number is considered a mechanical engineering topic. Research, independent study, and seminar units cannot count towards the 24 units of independent coursework.
5. *Approved Electives* (to bring the total number of units to at least 39): electives must be approved by an adviser. Graduate engineering, mathematics, and science courses above 200 level are normally approved. Approved electives must be taken for a letter grade. No more than 6 of the 39 units may come from ME 391/392 (or other independent study/research courses), and no more than 3 may come from seminars. Students planning a Ph.D. should discuss with their advisers the option of taking 391 or 392 during the master's program. ME 391/392 (and other independent study courses) may only be taken on a credit/no credit basis.
6. *Unrestricted electives* (to bring the total number of units submitted for the M.S. degree to 45): students are encouraged to take these units outside engineering, mathematics, or the sciences. Students should consult their advisers on course loads and on ways to use the unrestricted electives to make a manageable program. Unrestricted electives must have catalog numbers greater than 100. Unrestricted electives may be taken CR/NC.
7. Within the courses satisfying the requirements above, there must be at least one graduate-level course with a laboratory component. Courses which satisfy this requirement are:

		Units
ENGR 241	Advanced Micro and Nano Fabrication Laboratory	3
ME 203	Design and Manufacturing	4
ME 210	Introduction to Mechatronics	4
ME 218A	Smart Product Design Fundamentals	4-5
ME 218B	Smart Product Design Applications	4-5
ME 218C	Smart Product Design Practice	4-5
ME 218D	Smart Product Design: Projects	3-4
ME 220	Introduction to Sensors	3-4
ME 250	Internal Combustion Engines	3-5
ME 287	Mechanics of Biological Tissues	4
ME 310A	Engineering Design Entrepreneurship and Innovation: exploring the problem space	4
ME 310B	Engineering Design Entrepreneurship and Innovation: exploring the solution space	4
ME 310C	Engineering Design Entrepreneurship and Innovation: make it REAL	4
ME 318	Computer-Aided Product Creation	4
ME 323	Modeling and Identification of Mechanical Systems for Control	3
ME 324	Precision Engineering	4
ME 348	Experimental Stress Analysis	3
ME 354	Experimental Methods in Fluid Mechanics	4
ME 367	Optical Diagnostics and Spectroscopy Laboratory	4
ME 392	Experimental Investigation of Engineering Problems	1-10

Or other independent study courses may satisfy this requirement if 3 units are taken for work involving laboratory experiments

Candidates for the M.S. in Mechanical Engineering are expected to have the approval of the faculty; they must maintain a minimum grade point average (GPA) of 3.0 in the 45 units presented for fulfillment of degree requirements (exclusive of independent study courses). All courses used to fulfill mathematics, depth, breadth, approved electives, and lab studies must be taken for a letter grade (excluding seminars, independent study, and courses for which a letter grade is not an option for any student).

Students falling below a GPA of 2.5 at the end of 20 units may be disqualified from further registration. Students failing to meet the complete degree requirements at the end of 60 units of graduate registration are disqualified from further registration. Courses used to fulfill deficiencies arising from inadequate undergraduate preparation for mechanical engineering graduate work may not be applied to the 45 units required for completion of the MS degree.

Engineering

As described in the "School of Engineering" section of this bulletin, each department in the school may sponsor students in a more general degree, the M.S. in Engineering. Sponsorship by the Department of Mechanical Engineering (ME) requires (1) filing a petition for admission to the program by no later than the day before instruction begins, and (2) that the center of gravity of the proposed program lies in ME. No more than 18 units used for the proposed program may have been previously completed. The program must include at least 9 units of graduate-level work in the department other than ME 300A,B,C, seminars, and independent study. The petition must be accompanied by a statement explaining the program objectives and how it is coherent, contains depth, and fulfills a well-defined career objective. The grade requirements are the same as for the M.S. in Mechanical Engineering.

Master of Science in Engineering, Biomechanical Engineering

The Master of Science in Engineering: Biomechanical Engineering (MSE:BME) promotes the integration of engineering mechanics and design with the life sciences. Applicants are expected to have an additional exposure to biology and/or bioengineering in their undergraduate studies. Students planning for subsequent medical school studies are advised to contact Stanford's Premedical Advising Office in Sweet Hall.

Students wishing to pursue this program must complete the Graduate Program Authorization form and get approval from the Student Services Office. This form serves to officially add the field to the student's record. This form must be filled out electronically on Axess. The Mechanical Engineering Department does not have a coterminal Biomechanical Engineering Master's program.

Degree Requirements

1. Mathematical competence (minimum 6 units) in two of the following areas: partial differential equations, linear algebra, complex variables, or numerical analysis, as demonstrated by completion of two appropriate courses from the following list: ME300A,B,C; MATH106, 109, 113, 131M/P, 132; STATS110, or ENGR155C; CME108, 302. Students who have completed comparable graduate-level courses as an undergraduate, and who can demonstrate their competence to the satisfaction of the instructors of the Stanford courses, may be waived via petition from this requirement by their adviser and the Student Services Office. The approved equivalent courses should be placed in the approved electives category of the program proposal.
2. Graduate Level Engineering Courses (minimum 21 units), consisting of:
   a. Biomechanical engineering restricted electives (9 units) to be chosen from:

		Units
ME 239	Mechanics of the Cell	3
ME 281	Biomechanics of Movement	3
ME 287	Mechanics of Biological Tissues	4
ME 337	Mechanics of Growth	3
ME 381	Orthopaedic Bioengineering	3
ME 387	Soft Tissue Mechanics	3

   b. Specialty in engineering (9-12 units): A set of three or four graduate level courses in engineering mechanics, materials, controls, or design (excluding bioengineering courses) selected to provide depth in one area. Such sets are approved by the Mechanical Engineering Faculty. Comparable specialty sets composed of graduate engineering courses outside the Mechanical Engineering Department can be used with the approval of the student's adviser. Examples can be obtained from the Biomechanical Engineering Group Office (Durand 223).
   c. Graduate engineering electives (to bring the total number of graduate level engineering units to at least 21). These electives must contribute to a cohesive degree program, and be approved by the student's adviser. No units may come from bioengineering courses, mathematics courses, or seminars.
3. Life science approved electives (minimum 6 units): Undergraduate or graduate biological/medical science/chemistry courses which contribute to a cohesive program.
4. Biomechanical engineering seminar ME 389 Biomechanical Research Symposium.
5. General approved electives (to bring the total number of units to 39): These courses must be approved by the student's adviser. Graduate level engineering, math, and physical science courses and upper division undergraduate or graduate life science courses are normally approved.
6. Unrestricted electives (to bring the total number of units to 45): Students without undergraduate biology are encouraged to use some of these unrestricted units to strengthen their biology background. Students should consult their adviser for recommendations on course loads and on ways to use the unrestricted electives to create a manageable program. Unrestrictive electives must have catalog numbers greater than 100.

All courses except unrestricted electives must be taken for a letter grade unless letter grades are not an option. A minimum cumulative GPA of 3.0 is required for degree conferral.

Master of Science in Engineering, Design Impact

Note: The Master of Science, Product Design has been discontinued. For the most up to date description, please review AY 2016-17 bulletin.

The Master's Program in Design Impact is project-driven, highly immersive, and based on design thinking, the human-centered design process pioneered at Stanford. We teach the process, mindsets and skills needed to lead high-impact design teams. In our work on products, services, systems, and experiences, empathy is our guiding principle. Students completing the two-year program will earn a Master's of Science in Engineering degree with a concentration in Design Impact (MSE-Design Impact).

Degree Requirements

In the first year, students take all their classes together as a cohort. In the second year, students will continue to work together in the year-long "Design Impact" course (ME316A,B,C: Design Master's Project), each selecting to work on a project related to one of the two Impact themes. This sequence of classes will be the culmination of their educational experience and launch them into their individual careers as designers.

The student will select electives in second year with their advisor. The elective will be one of two types: focused on building a deep learning in the student's chosen Impact theme area and expanding the student's skill set and design toolkit. Appropriate electives are described below (5).

Candidates for the Design Impact Engineering Master's Degree are expected to have the approval to graduate from the faculty, and a minimum GPA of 3.0 in the 58 units completed in the program.

		Units
ME 313	Human Values and Innovation in Design	3
ME 203	Design and Manufacturing [1]	4
ME 277	Graduate Design Research Techniques	3
CS 106A	Programming Methodology [2]	3
ME 341	Design Experiments	3
ME 311	Leading Design Teams [3]	3
ME 216M	Introduction to the Design of Smart Products	3-4
ME 312	Communication in Design	3
ME or MS&E -Business Considerations in Design [4]		3
ME 316A	Design Impact Master's Project I [5]	4
ME 316B	Design Impact Master's Project II [5]	4
ME 316C	Design Impact Master's Project III [5]	4
ME 391	Engineering Problems	2
Approved Elective Units [6]		15

1 ME 203 should be completed in the first year, Autumn Quarter of the degree program.

2 CS106A is should be completed in the first year, Winter Quarter of the degree program. It is for students who have had limited exposure to computer programming and want to start at the introductory level. Students who have already had an introduction to computer science, or who have professional programming experience, should consider taking CS106B or consult with their advisor on the best-fit computer science class. If a different CS course is selected, it must be completed in the Winter term of the first year of the Master's degree program.

3 May substitute ME 368 d.Leadership .

4 A course that teaches Business Considerations in Design will be selected by the student in consultation with their advisor. Options include: ME 215C Analytical Product Design , MS&E 140X Financial Accounting Concepts and Analysis, and ACCT 317 Managerial Accounting: Performance Measurement, Compensation, and Governance.

5 ME 316A, B & C are taken sequentially for three quarters during the second year.

6 Students will choose courses at the 200 level or higher, from any of the Schools at the University to fulfill their elective requirement. Electives must be selected to fulfill education and career objectives and be related to their selected theme area within the Design Impact program. The advisor must sign off on electives prior to the students committing to taking them.

Note: All required classes and electives must be taken for a letter grade unless:

1) The class is not offered for a letter grade, OR

2) Prior approval has been granted to take a class CR/NC.

Engineer in Mechanical Engineering

The basic University requirements for the degree of Engineer are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin.

This degree requires an additional year of study beyond the M.S. degree and includes a research thesis. The program is designed for students who wish to do professional engineering work upon graduation and who want to engage in more specialized study than is afforded by the master's degree alone.

Admission standards are substantially the same as indicated under the master's degree. However, since thesis supervision is required and the availability of thesis supervisors is limited, admission is not granted until the student has personally engaged a faculty member to supervise a research project. This most often involves a paid research assistantship awarded by individual faculty members (usually from the funds of sponsored research projects under their direction). Thus, individual arrangement between student and faculty is necessary. Students studying for the M.S. degree at Stanford who wish to continue to the Engineer degree ordinarily make such arrangements during the M.S. degree program. Students holding master's degrees from other universities are invited to apply and may be admitted providing they are sufficiently well qualified and have made thesis supervision and financial aid arrangements.

Department requirements for the degree include a thesis; up to 18 units of credit are allowed for thesis work (ME 400 Thesis). In addition to the thesis, 27 units of approved advanced course work in mathematics, science, and engineering are expected beyond the requirements for the M.S. degree; the choice of courses is subject to approval of the adviser. Students who have not fulfilled the Stanford M.S. degree requirements are required to do so, with allowance for approximate equivalence of courses taken elsewhere; up to 45 units may be transferable. A total of 90 units is required for degree conferral.

Candidates for the degree must have faculty approval and have a minimum grade point average (GPA) of 3.0 for all courses (exclusive of thesis credit and other independent study courses) taken beyond those required for the master's degree.

Doctor of Philosophy in Mechanical Engineering

The basic University requirements for the Ph.D. degree are discussed in the "Graduate Degree" section of this bulletin. The Ph.D. degree is intended primarily for students who desire a career in research, advanced development, or teaching; for this type of work, a broad background in mathematics and the engineering sciences, together with intensive study and research experience in a specialized area, are the necessary requisites.

Ph.D. students must have a master's degree from another institution, or must fulfill the requirements for the Stanford M.S. degree in Mechanical Engineering or another discipline.

In special situations dictated by compelling academic reasons, Academic Council members who are not members of the department's faculty may serve as the principal dissertation adviser when approved by the department. In such cases, a member of the department faculty must serve as program adviser and as a member of the reading committee, and agree to accept responsibility that department procedures are followed and standards maintained.

Admission involves much the same consideration described under the Engineer degree. Since thesis supervision is required, admission is not granted until the student has personally engaged a member of the faculty to supervise a research project. Once a student has obtained a research supervisor, this supervisor becomes thereafter the student's academic adviser. Research supervisors may require that the student pass the departmental qualifying examination before starting research and before receiving a paid research assistantship. Note that research assistantships are awarded by faculty research supervisors and not by the department.

Prior to being formally admitted to candidacy for the Ph.D. degree, the student must demonstrate knowledge of engineering fundamentals by passing a qualifying examination. The academic level and subject matter of the examination correspond approximately to the M.S. program described above. Typically, the exam is taken in the second year of a students PhD program. The student is required to have a minimum graduate Stanford GPA of 3.5 to be eligible for the exam (grades from independent study courses are not included in the GPA calculation). More information on the qualifying examination process can be found in the ME Graduate student handbook, provide online by the student services office.

Ph.D. candidates must complete a minimum of 21 units (taken for a letter grade) of approved formal course work (excluding research, directed study, and seminars) in advanced study beyond the M.S. degree. The courses should consist primarily of graduate courses in engineering and sciences, although the candidate's adviser may approve a limited number of upper-level undergraduate courses via petition and courses outside of engineering and sciences, as long as such courses contribute to a strong and coherent program. In addition to this 21-unit requirement, all Ph.D. candidates should participate each quarter in one of the following (or equivalent) seminars:

		Units
ME 389	Biomechanical Research Symposium	1
ME 390	Thermosciences Research Project Seminar	1
ME 395	Seminar in Solid Mechanics	1
ME 397	Design Theory and Methodology Seminar	1-3
AA 297	Seminar in Guidance, Navigation, and Control	1
ENGR 298	Seminar in Fluid Mechanics	1
ENGR 311A/311B	Women's Perspectives	1

The department has a breadth requirement for the Ph.D. degree. This may be satisfied either by a formal minor in another department (generally 20 units) or by at least 9 units of course work (outside of the primary research topic) which are approved by the principal dissertation adviser. If a minor is taken, 9 units from the minor requirements can be counted towards the depth requirement.

The Ph.D. thesis normally represents at least one full year of research work and must be a substantial contribution to the field. Students may register for course credit for thesis work (ME 500) to help fulfill University academic unit requirements, but there is no minimum limit on registered dissertation units, as long as students are registered in at least 8 units (10 is recommended) per quarter prior to TGR. Candidates should note that only completed course units are counted toward the requirement, so ungraded courses or courses with an "N" grade must be cleared before going TGR. Questions should be directed to the department student services office.

The final University oral examination (dissertation defense) is conducted by a committee consisting of a chair from another department and four faculty members of the department or departments with related interests. Usually, the committee includes the candidate's adviser, reading committee members, plus two more faculty. The examination consists of two parts. The first is open to the public and is scheduled as a seminar talk, usually for one of the regular meetings of a seminar series. The second is conducted in private and covers subjects closely related to the dissertation topic.

Ph.D. Minor in Mechanical Engineering

Students who wish a Ph.D. minor in ME should consult with the ME student services office. A minor in ME may be obtained by completing 20 units of approved graduate-level ME courses. Courses approved for the minor must form a coherent program and must be chosen from those satisfying requirement 2 for the M.S. in Mechanical Engineering.

See the *Mechanical Engineering Graduate Student Handbook* produced by the Mechanical Engineering student services office for more information.

Graduate Advising Expectations

The Department of Mechanical Engineering is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising (http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext)" section of this bulletin.

Emeriti: (Professors) James L. Adams, Thomas P. Andriacchi, David M. Barnett, Peter Bradshaw, Brian J. Cantwell, Dennis R. Carter, Daniel B. DeBra, Robert H. Eustis, Thomas J. R. Hughes, James P. Johnston, Thomas R. Kane, William M. Kays, Joseph B. Keller, Charles H. Kruger, Robert H. McKim, Robert J. Moffat, M. Godfrey Mungal, J. David Powell, Charles R. Steele*, Douglass J. Wilde; *(Professors, Research)* Richard M. Christensen, Sidney A. Self, Kenneth J. Waldron*, Felix E. Zajac

Chair: Kenneth E. Goodson

Group Chairs: Mark R. Cutkosky & Sheri D. Sheppard (Design), Marc Levenston (Biomechanical Engineering), Gianluca Iaccarino & Parviz Moin (Flow Physics and Computational Engineering), Wei Cai (Mechanics and Computation), Christopher F. Edwards (Thermosciences)

Professors: Craig T. Bowman, Mark A. Cappelli, Mark R. Cutkosky, John Dabiri, Scott L. Delp, John K. Eaton, Christopher F. Edwards, Charbel Farhat, J. Christian Gerdes, Kenneth E. Goodson, Ronald K. Hanson, Gianluca Iaccarino, David M. Kelley, Thomas W. Kenny, Ellen Kuhl, Larry J. Leifer, Sanjiva K. Lele, Arun Majumdar, Reginald E. Mitchell, Parviz Moin, Drew V. Nelson, Allison M. Okamura, Peter M. Pinsky, Friedrich B. Prinz, Beth L. Pruitt, Bernard Roth, Juan G. Santiago, Eric S. G. Shaqfeh, Sheri D. Sheppard, Hai Wang

Associate Professors: Wei Cai, Steve Collins, Eric F. Darve, W. Matthias Ihme, Marc E. Levenston, Adrian J. Lew, Ali Mani, Xiaolin Zheng

Assistant Professors: Ovijit Chaudhuri, Sean Follmer, Wendy Gu, David Lentink, Erin MacDonald, Sindy K.-Y. Tang

Professor (Teaching): David W. Beach

Courtesy Professors: Oussama Khatib, Paul Yock

Courtesy Associate Professor: Nicholas Giori, Christian Linder

Courtesy Assistant Professor: David Camarillo, Roseanna Zia

Senior Lecturers: Vadim Khayms, J. Craig Milroy

Adjunct Professors: Mehdi Asheghi, Michael R. Barry, William R. Burnett, J. Edward Carryer, Rainer J. Fasching, Shannon Gilmartin, John A. Howard, Barry M. Katz, Paul Mitiguy, Gary O'Brien, Dev Patnaik, Paul Saffo III, George Toye

* Recalled to active duty.

Cognate Courses

		Units
CS 106A	Programming Methodology	3-5
CS 223A	Introduction to Robotics	3
ENGR 14	Intro to Solid Mechanics	3
ENGR 15	Dynamics	3
ENGR 40	Introductory Electronics	5
ENGR 70A	Programming Methodology	3-5
ENGR 105	Feedback Control Design	3
ENGR 205	Introduction to Control Design Techniques	3
ENGR 209A	Analysis and Control of Nonlinear Systems	3
ENGR 240	Introduction to Micro and Nano Electromechanical Systems	3
ENGR 341	Micro/Nano Systems Design and Fabrication	3-5

Overseas Studies Courses in Mechanical Engineering

The Bing Overseas Studies Program (http://bosp.stanford.edu) manages Stanford study abroad programs for Stanford undergraduates. Students should consult their department or program's student services office for applicability of Overseas Studies courses to a major or minor program.

The Bing Overseas Studies course search site (https://undergrad.stanford.edu/programs/bosp/explore/search-courses) displays courses, locations, and quarters relevant to specific majors.

For course descriptions and additional offerings, see the listings in the Stanford Bulletin's ExploreCourses (http://explorecourses.stanford.edu) or Bing Overseas Studies (http://bosp.stanford.edu).

		Units
OSPFLOR 66	The Engineering of Opera	3
OSPKYOTO 21	Japanese Woodworking & Contemporary Sculpture	4