School of Engineering

Courses offered by the School of Engineering are listed under the subject code ENGR on the (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=ENGR&filter-catalognumber-ENGR=on) Stanford Bulletin's (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=ENGR&filter-catalognumber-ENGR=on) ExploreCourses web site (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=ENGR&filter-catalognumber-ENGR=on).

The School of Engineering offers undergraduate programs leading to the degree of Bachelor of Science (B.S.), programs leading to both B.S. and Master of Science (M.S.) degrees, other programs leading to a B.S. with a Bachelor of Arts (B.A.) in a field of the humanities or social sciences, dual-degree programs with certain other colleges, and graduate curricula leading to the degrees of M.S., Engineer, and Ph.D.

The school has nine academic departments: Aeronautics and Astronautics, Bioengineering, Chemical Engineering, Civil and Environmental Engineering, Computer Science, Electrical Engineering, Management Science and Engineering, Materials Science and Engineering, and Mechanical Engineering. These departments and one interdisciplinary program, the Institute for Computational and Mathematical Engineering, are responsible for graduate curricula, research activities, and the departmental components of the undergraduate curricula.

In research where faculty interest and competence embrace both engineering and the supporting sciences, there are numerous programs within the school as well as several interschool activities, including the Army High Performance Computing Research Center, Biomedical Informatics Training Program, Center for Integrated Systems, Center for Work, Technology, and Organization, Collaboratory for Research on Global Projects, National Center for Physics-Based Simulation in Biology, Center for Position, Navigation, and Time, the Energy Modeling Forum, the NIH Biotechnology Graduate Training Grant in Chemical Engineering, and the Stanford Technology Ventures Program. Energy Resources Engineering (formerly Petroleum Engineering) is offered through the School of Earth Sciences.

The School of Engineering's Hasso Plattner Institute of Design (http://dschool.stanford.edu) brings together students and faculty in engineering, business, education, medicine, and the humanities to learn design thinking and work together to solve big problems in a human-centered way.

The Woods Institute for the Environment (http://environment.stanford.edu) brings together faculty, staff, and students from the schools, institutes and centers at Stanford to conduct interdisciplinary research, education, and outreach to promote an environmentally sound and sustainable world.

The Global Engineering Program offers a portfolio of international opportunities for Stanford undergraduate and graduate students majoring within the School of Engineering. Opportunities range from service learning programs to internships to study tours. These opportunities enhance engineering education by providing students with an opportunity to learn about technology and engineering globally, to build professional networks, and to gain real world experience in a culturally diverse and international environment. For more information and application deadlines, please see gep.stanford.edu

Instruction in Engineering is offered primarily during Autumn, Winter, and Spring quarters of the regular academic year. During the Summer Quarter, a small number of undergraduate and graduate courses are offered.

Undergraduate Programs in the School of Engineering

The principal goals of the undergraduate engineering curriculum are to provide opportunities for intellectual growth in the context of an engineering discipline, for the attainment of professional competence, and for the development of a sense of the social context of technology. The curriculum is flexible, with many decisions on individual courses left to the student and the adviser. For a student with well-defined educational goals, there is often a great deal of latitude.

In addition to the special requirements for engineering majors described below, all undergraduate engineering students are subject to the University general education, writing, and foreign language requirements outlined in the first pages of this bulletin. Depending on the program chosen, students have the equivalent of from one to three quarters of free electives to bring the total number of units to 180.

The School of Engineering's *Handbook for Undergraduate Engineering Programs* is the definitive reference for all undergraduate engineering programs. It is available online at http://ughb.stanford.edu and provides detailed descriptions of all undergraduate programs in the school, as well as additional information about extracurricular programs and services. Because it is revised in the summer, and updates are made to the web site on a continuing basis, the handbook reflects the most up-to-date information on School of Engineering programs for the academic year.

Accreditation

The Accreditation Board for Engineering and Technology (ABET) accredits college engineering programs nationwide using criteria and standards developed and accepted by U.S. engineering communities. At Stanford, the following undergraduate programs are accredited:

- Chemical Engineering
- Civil Engineering
- Mechanical Engineering

In ABET-accredited programs, students must meet specific requirements for engineering science, engineering design, mathematics, and science course work. Students are urged to consult the School of Engineering Handbook for Undergraduate Engineering Programs and their adviser.

Accreditation is important in certain areas of the engineering profession; students wishing more information about accreditation should consult their department office or the office of the Senior Associate Dean for Student Affairs in 135 Huang Engineering Center.

Policy on Satisfactory/ No Credit Grading and Minimum Grade Point Average

All courses taken to satisfy major requirements (including the requirements for mathematics, science, engineering fundamentals, Technology in Society, and engineering depth) for all engineering students (including both department and School of Engineering majors) must be taken for a letter grade if the instructor offers that option.

For departmental majors, the minimum combined GPA (grade point average) for all courses taken in fulfillment of the Engineering Fundamentals requirement and the Engineering Depth requirement is 2.0. For School of Engineering majors, the minimum GPA on all engineering courses taken in fulfillment of the major requirements is 2.0.

Admission

Any students admitted to the University may declare an engineering major if they elect to do so; no additional courses or examinations are required for admission to the School of Engineering.

Recommended Preparation

Freshman

Students who plan to enter Stanford as freshmen and intend to major in engineering should take the highest level of mathematics offered in high school. (See the "Mathematics (http://www.stanford.edu/dept/registrar/bulletin/6023.htm)" section of this bulletin for information on advanced placement in mathematics.) High school courses in physics and chemistry are strongly recommended, but not required. Additional elective course work in the humanities and social sciences is also recommended.

Transfer Students

Students who do the early part of their college work elsewhere and then transfer to Stanford to complete their engineering programs should follow an engineering or pre-engineering program at the first school, selecting insofar as possible courses applicable to the requirements of the School of Engineering, that is, courses comparable to those described under "Undergraduate Programs (http://www.stanford.edu/dept/registrar/bulletin/5144.htm)." In addition, students should work toward completing the equivalent of Stanford's foreign language requirement and as many of the University's General Education Requirements (GERs) as possible before transferring. Some transfer students may require more than four years (in total) to obtain the B.S. degree. However, Stanford affords great flexibility in planning and scheduling individual programs, which makes it possible for transfer students, who have wide variations in preparation, to plan full programs for each quarter and to progress toward graduation without undue delay.

Transfer credit is given for courses taken elsewhere whenever the courses are equivalent or substantially similar to Stanford courses in scope and rigor. The policy of the School of Engineering is to study each transfer student's preparation and make a reasonable evaluation of the courses taken prior to transfer by means of a petition process. Inquiries may be addressed to the Office of Student Affairs in 135 Huang Engineering Center. For more information, see the transfer credit section of the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu.

Degree Program Options

In addition to the B.S. degrees offered by departments, the School of Engineering offers two other types of B.S. degrees:

- Bachelor of Science in Engineering (see subplan majors listed below)
- Bachelor of Science for Individually Designed Majors in Engineering (IDMEN)

There are seven Engineering B.S. subplans that have been proposed by cognizant faculty groups and pre-approved by the Undergraduate Council:

- Aeronautics and Astronautics
- Architectural Design
- Atmosphere/Energy
- Biomechanical Engineering
- Biomedical Computation
- Engineering Physics
- Product Design.

The B.S. for an Individually Designed Major in Engineering has also been approved by the council.

Curricula for majors are offered by the departments of:

- Bioengineering
- Chemical Engineering
- Civil and Environmental Engineering
- Computer Science
- Electrical Engineering
- Management Science and Engineering
- Materials Science and Engineering
- Mechanical Engineering

Curricula for majors in these departments have the following components:

- 36-45 units of mathematics and science (see Basic Requirements 1 and 2 at the end of this section)
- engineering fundamentals (three course minimum, at least one of which must be unspecified by the department, see Basic Requirement 3)
- Technology in Society (TIS) (one course minimum, see Basic Requirement 4)
- engineering depth (courses such that the total number of units for Engineering Fundamentals and Engineering Depth is between 60 and 72)
- ABET accredited majors must meet a minimum number of Engineering Science and Engineering Design units; (see Basic Requirement 5)

Consult the 2015-16 Handbook for Undergraduate Engineering Programs (http://ughb.stanford.edu) for additional information.

Dual and Coterminal Programs

A Stanford undergraduate may work simultaneously toward two bachelor's degrees or toward a bachelor's and a master's degree, that is, B.A. and M.S., B.A. and M.A., B.S. and M.S., or B.S. and M.A. The degrees may be granted simultaneously or at the conclusion of different quarters. Five years are usually required for a dual or coterminal program or for a combination of these two multiple degree programs. For further information, inquire with the School of Engineering's student affairs office, 135 Huang Engineering Center, or with department contacts listed in the Handbook for Undergraduate Engineering Programs, available at http://ughb.stanford.edu.

Dual B.A. and B.S. Degree Program—To qualify for both degrees, a student must:

1. complete the stated University and department requirements for each degree
2. complete 15 full-time quarters, or 3 full-time quarters after completing 180 units
3. complete a total of 225 units (180 units for the first bachelor's degree plus 45 units for the second bachelor's degree)

Coterminal Bachelor's and Master's Degree Program—A Stanford undergraduate may be admitted to graduate study for the purpose of working simultaneously toward a bachelor's degree and a master's degree, in the same or different disciplines. To qualify for both degrees, a student must:

1. complete, in addition to the units required for the bachelor's degree, the number of units required by the graduate department for the master's degree which in no event is fewer than the University minimum of 45 units
2. complete the requirements for the bachelor's degree (department, school, and University) and apply for conferral of the degree at the appropriate time
3. complete the department and University requirements for the master's degree and apply for conferral of the degree at the appropriate time

A student may complete the bachelor's degree before completing the master's degree, or both degrees may be completed in the same quarter.

Procedure for Applying for Admission to Coterminal Degree Programs

Stanford undergraduates apply to the pertinent graduate department using the University coterminal application. Application deadlines and admissions criteria vary by department, but in all cases the student must apply early enough to allow a departmental decision at least one quarter in advance of the anticipated date of conferral of the bachelor's degree.

Students interested in coterminal degree programs in Engineering should refer to our departments' sections of this bulletin for more detailed information. The University requirements for the coterminal master's degree are described in the "Coterminal Master's Degrees (http://exploredegrees.stanford.edu/cotermdegrees/#text)" section of this bulletin.

Graduate Programs in the School of Engineering

Admission

Application for admission with graduate standing in the school should be made to the graduate admissions committee in the appropriate department or program. While most graduate students have undergraduate preparation in an engineering curriculum, it is feasible to enter from other programs, including chemistry, geology, mathematics, or physics.

For further information and application instructions, see the department sections in this bulletin or http://gradadmissions.stanford.edu. Stanford undergraduates may also apply as coterminal students; details can be found under "Degree Program Options" in the "Undergraduate Programs in the School of Engineering (http://www.stanford.edu/dept/registrar/bulletin/5144.htm)" section of this bulletin.

Fellowships and Assistantships

Departments and divisions of the School of Engineering award graduate fellowships, research assistantships, and teaching assistantships each year.

Curricula in the School of Engineering

For further details about the following programs, see the department sections in this bulletin.

Related aspects of particular areas of graduate study are commonly covered in the offerings of several departments and divisions. Graduate students are encouraged, with the approval of their department advisers, to choose courses in departments other than their own to achieve a broader appreciation of their field of study. For example, most departments in the school offer courses concerned with nanoscience, and a student interested in an aspect of nanotechnology can often gain appreciable benefit from the related courses given by departments other than her or his own.

Departments and programs of the school offer graduate curricula as follows:

Aeronautics and Astronautics

- Aeroelasticity and Flow Simulation
- Aircraft Design, Performance, and Control
- Applied Aerodynamics
- Autonomy
- Computational Aero-Acoustics
- Computational Fluid Dynamics
- Computational Mechanics and Dynamical Systems
- Control of Robots, including Space and Deep-Underwater Robots
- Conventional and Composite Materials and Structures
- Decision Making under Uncertainty
- Direct and Large-Eddy Simulation of Turbulence
- High-Lift Aerodynamics
- Hybrid Propulsion
- Hypersonic and Supersonic Flow
- Micro and Nano Systems and Materials
- Multidisciplinary Design Optimization
- Navigation Systems (especially GPS)
- Optimal Control, Estimation, System Identification
- Sensors for Harsh Environments
- Space Debris Characterization
- Space Environment Effects on Spacecraft
- Space Plasmas
- Spacecraft Design and Satellite Engineering
- Turbulent Flow and Combustion

Bioengineering

- Biomedical Computation
- Biomedical Devices
- Biomedical Imaging
- Cell and Molecular Engineering
- Regenerative Medicine

Chemical Engineering

- Applied Statistical Mechanics
- Biocatalysis
- Biochemical Engineering
- Bioengineering
- Biophysics
- Computational Materials Science
- Colloid Science
- Dynamics of Complex Fluids
- Energy Conversion
- Functional Genomics
- Hydrodynamic Stability
- Kinetics and Catalysis
- Microrheology
- Molecular Assemblies
- Nanoscience and Technology
- Newtonian and Non-Newtonian Fluid Mechanics
- Polymer Physics
- Protein Biotechnology
- Renewable Fuels
- Semiconductor Processing
- Soft Materials Science
- Solar Utilization
- Surface and Interface Science
- Transport Mechanics

Civil and Environmental Engineering

- Atmosphere/Energy
- Construction Engineering and Management
- Design/Construction Integration
- Environmental Engineering and Science
- Environmental Fluid Mechanics and Hydrology

- Environmental and Water Studies
- Geomechanics
- Structural Engineering
- Sustainable Design and Construction

Computational and Mathematical Engineering

- Applied and Computational Mathematics
- Computational Biology
- Computational Fluid Dynamics
- Computational Geometry and Topology
- Computational Geosciences
- Computational Medicine
- Data Science
- Discrete Mathematics and Algorithms
- Numerical Analysis
- Optimization
- Partial Differential Equations
- Stochastic Processes
- Uncertainty Quantification
- Financial Mathematics

Computer Science

See http://forum.stanford.edu/research/areas.php for a comprehensive list.

- Algorithmic Game Theory
- Artificial Intelligence
- Autonomous Agents
- Biomedical Computation
- Compilers
- Complexity Theory
- Computational and Cognitive Neuroscience
- Computational Biology
- Computational Geometry and Topology
- Computational Logic
- Computational Photography
- Computational Physics
- Computer Architecture
- Computer Graphics
- Computer Security
- Computer Science Education
- Computer Vision
- Crowdsourcing
- Cryptography
- Database Systems
- Data Center Computing
- Data Mining
- Design and Analysis of Algorithms
- Digital Libraries
- Distributed and Parallel Computation
- Distributed Systems
- Electronic Commerce
- Formal Verification
- General Game Playing
- Haptic Display of Virtual Environments
- Human-Computer Interaction
- Image Processing
- Information and Communication Technologies for Development
- Information Management
- Learning Theory
- Machine Learning
- Mathematical Theory of Computation
- Mobile Computing
- Multi-Agent Systems
- Nanotechnology-enabled Systems
- Natural Language and Speech Processing
- Networking and Internet Architecture
- Operating Systems
- Parallel Computing
- Probabilistic Models and Methods
- Programming Systems/Languages
- Robotics
- Robust System Design
- Scientific Computing and Numerical Analysis
- Sensor Networks
- Social and Information Networks
- Social Computing
- Ubiquitous and Pervasive Computing
- Visualization
- Web Application Infrastructure

Electrical Engineering

- Biomedical Devices and Bioimaging
- Communication Systems: Wireless, Optical, Wireline
- Control, Learning, and Optimization
- Electronic and Magnetic Devices
- Energy: Solar Cells, Smart Grid, Load Control
- Environmental and Remote Sensing: Sensor Nets, Radar Systems, Space
- Fields and Waves
- Graphics, HCI, Computer Vision, Photography
- Information Theory and Coding: Image and Data Compression, Denoising
- Integrated Circuit Design: MEMS, Sensors, Analog, RF
- Network Systems and Science: Nest Gen Internet, Wireless Networks
- Nano and Quantum Science
- Photonic Devices
- Systems Software: OS, Compilers, Languages
- Systems Hardware: Architecture, VLSI, Embedded Systems
- VLSI Design

Management Science and Engineering

- Decision and Risk Analysis
- Dynamic Systems
- Economics
- Entrepreneurship
- Finance
- Information
- Marketing
- Optimization
- Organization Behavior
- Organizational Science

- Policy
- Production
- Stochastic Systems
- Strategy

Materials Science and Engineering

- Biomaterials
- Ceramics and Composites
- Computational Materials Science
- Electrical and Optical Behavior of Solids
- Electron Microscopy
- Fracture and Fatigue
- Imperfections in Crystals
- Kinetics
- Magnetic Behavior of Solids
- Magnetic Storage Materials
- Nanomaterials
- Photovoltaics
- Organic Materials
- Phase Transformations
- Physical Metallurgy
- Solid State Chemistry
- Structural Analysis
- Thermodynamics
- Thin Films
- X-Ray Diffraction

Mechanical Engineering

- Biomechanics
- Combustion Science
- Computational Mechanics
- Controls
- Design of Mechanical Systems
- Dynamics
- Environmental Science
- Experimental Stress and Analysis
- Fatigue and Fracture Mechanics
- Finite Element Analysis
- Fluid Mechanics
- Heat Transfer
- High Temperature Gas Dynamics
- Kinematics
- Manufacturing
- Mechatronics
- Product Design
- Robotics
- Sensors
- Solids
- Thermodynamics
- Turbulence

For more information on the ME graduate curriculum, please see the Graduate Bulletin and Graduate student handbook.

Bachelor of Science in the School of Engineering

Departments within the School of Engineering offer programs leading to the B.S. degree in the following fields:

- Bioengineering
- Chemical Engineering
- Civil Engineering
- Computer Science
- Electrical Engineering
- Environmental Systems Engineering
- Management Science and Engineering
- Materials Science and Engineering
- Mechanical Engineering

The School of Engineering itself offers interdisciplinary programs leading to the B.S. degree in Engineering with specializations in:

- Aeronautics and Astronautics
- Architectural Design
- Atmosphere/Energy
- Biomechanical Engineering
- Biomedical Computation
- Engineering Physics
- Product Design

In addition, students may elect a B.S. in an Individually Designed Major in Engineering.

Bachelor of Arts and Science (B.A.S.) in the School of Engineering

This degree is available to students who complete both the requirements for a B.S. degree in engineering and the requirements for a major or program ordinarily leading to the B.A. degree. For more information, see the "Undergraduate Degrees (http://exploredegrees.stanford.edu/undergraduatedegreesandprograms/#bachelorstext)" section of this bulletin.

Independent Study, Research, and Honors

The departments of Chemical Engineering, Civil and Environmental Engineering, Computer Science, Electrical Engineering, and Mechanical Engineering, as well as the faculty overseeing the Architectural Design, Atmosphere/Energy, Bioengineering, Biomechanical Engineering, Biomedical Computing, and Engineering Physics majors, offer qualified students opportunities to do independent study and research at an advanced level with a faculty mentor in order to receive a Bachelor of Science with honors. An honors option is also available to students pursuing an independently designed major, with the guidance and approval of their adviser.

Petroleum Engineering

Petroleum Engineering is offered by the Department of Energy Resource Engineering in the School of Earth, Energy, and Environmental Sciences. Consult the "Energy Resources Engineering (http://exploredegrees.stanford.edu/schoolofearthsciences/energyresourcesengineering)" section of this bulletin for requirements. School of Engineering majors who anticipate summer jobs or career positions associated with the oil industry should consider enrolling in ENGR 120.

Programs in Manufacturing

Programs in manufacturing are available at the undergraduate, master's, and doctorate levels. The undergraduate programs of the departments of Civil and Environmental Engineering, Management Science and Engineering, and Mechanical Engineering provide general preparation for any student interested in manufacturing. More specific interests can be accommodated through Individually Designed Majors in Engineering (IDMENs).

Basic Requirements

Basic Requirement 1 (Mathematics)

Engineering students need a solid foundation in the calculus of continuous functions, linear algebra, an introduction to discrete mathematics, and an understanding of statistics and probability theory. Students are encouraged to select courses on these topics. To meet ABET accreditation criteria, a student's program must include the study of differential equations. Courses that satisfy the math requirement are listed at http://ughb.stanford.edu in the Handbook for Undergraduate Engineering Programs.

Basic Requirement 2 (Science)

A strong background in the basic concepts and principles of natural science in such fields as physics, chemistry, geology, and biology is essential for engineering. Most students include the study of physics and chemistry in their programs. Courses that satisfy the science requirement are listed at http://ughb.stanford.edu in the Handbook for Undergraduate Engineering Programs.

Basic Requirement 3 (Engineering Fundamentals)

The Engineering Fundamentals requirement is satisfied by a nucleus of technically rigorous introductory courses chosen from the various engineering disciplines. It is intended to serve several purposes. First, it provides students with a breadth of knowledge concerning the major fields of endeavor within engineering. Second, it allows the incoming engineering student an opportunity to explore a number of courses before embarking on a specific academic major. Third, the individual classes each offer a reasonably deep insight into a contemporary technological subject for the interested non-engineer.

The requirement is met by taking three courses from the following list, at least one of which is chosen by the student rather than by the department:

		Units
ENGR 10	Introduction to Engineering Analysis	4
ENGR 14	Intro to Solid Mechanics	4
ENGR 15	Dynamics	4
ENGR 20	Introduction to Chemical Engineering (same as CHEMENG 20)	3
ENGR 25B	Biotechnology [1]	3
ENGR 25E	Energy: Chemical Transformations for Production, Storage, and Use (same as CHEMENG 25E) [1]	3
ENGR 30	Engineering Thermodynamics	3
ENGR 40	Introductory Electronics [1,2]	5
ENGR 40A	Introductory Electronics	3
ENGR 40M	An Intro to Making: What is EE	3-5
ENGR 40P	Physics of Electrical Engineering [1]	5
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis [1,2]	4
ENGR 50E	Introduction to Materials Science, Energy Emphasis [1]	4
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis [1]	4
ENGR 60	Engineering Economy	3
ENGR 62	Introduction to Optimization (same as MS&E 111)	4
ENGR 70A/CS 106A	Programming Methodology [1]	5
ENGR 70B/CS 106B	Programming Abstractions [1]	5
ENGR 70X/CS 106X	Programming Abstractions (Accelerated) [1]	5
ENGR 80	Introduction to Bioengineering (Engineering Living Matter) (same as BIOE 80)	4
ENGR 90	Environmental Science and Technology (same as CEE 70)	3

1 Only one course from each numbered series can be used in the Engineering Fundamentals category within a major program.

2 ENGR 40 Introductory Electronics and ENGR 50 Introduction to Materials Science, Nanotechnology Emphasis may be taken on video at some of Stanford's Overseas Centers.

Basic Requirement 4 (Technology in Society)

It is important for the student to obtain a broad understanding of engineering as a social activity. To foster this aspect of intellectual and professional development, all engineering majors must take one course devoted to exploring issues arising from the interplay of engineering, technology, and society. Courses that fulfill this requirement are listed online at http://ughb.stanford.edu in the Handbook for Undergraduate Engineering Programs.

Basic Requirement 5 (Engineering Topics)

In order to satisfy ABET (Accreditation Board for Engineering and Technology) requirements, a student majoring in Chemical, Civil, or Mechanical Engineering must complete one and a half years of engineering topics, consisting of a minimum of 68 units of Engineering Fundamentals and Engineering Depth appropriate to the student's field of study. In most cases, students meet this requirement by completing the major program core and elective requirements. A student may need to take additional courses in Depth in order to fulfill the minimum requirement. Appropriate courses assigned to fulfill each major's program are listed online at http://ughb.stanford.edu in the Handbook for Undergraduate Engineering Programs.

Experimentation

Chemical Engineering, Civil Engineering, and Mechanical Engineering must include experimental experience appropriate to the discipline. Lab courses taken in the sciences, as well as experimental work taken in courses within the School of Engineering, will fulfill this requirement.

Overseas Studies Courses in Engineering

For course descriptions and additional offerings, see the listings in the Stanford Bulletin's ExploreCourses web site (http://explorecourses.stanford.edu) or the Bing Overseas Studies web site (http://bosp.stanford.edu). Students should consult their department or program's student services office for applicability of Overseas Studies courses to a major or minor program.

Aeronautics and Astronautics (AA)

Mission of the Undergraduate Program in Aeronautics and Astronautics

The mission of the undergraduate program in Aeronautics and Astronautics Engineering is to provide students with the fundamental principles and techniques necessary for success and leadership in the conception, design, implementation, and operation of aerospace and related engineering systems. Courses in the major introduce students to engineering principles. Students learn to apply this fundamental knowledge to conduct laboratory experiments and aerospace system design problems. Courses in the major include engineering fundamentals, mathematics, and the sciences, as well as in-depth courses in aeronautics and astronautics, dynamics, mechanics of materials, fluids engineering, and heat transfer. The major prepares students for careers in aircraft and spacecraft engineering, space exploration, air and space-based telecommunication industries, teaching, research, military service, and many related technology-intensive fields.

Completion of the undergraduate program in Aeronautics and Astronautics leads to the conferral of the Bachelor of Science in Engineering. The subplan "Aeronautics and Astronautics" appears on the transcript and on the diploma.

Requirements

		Units
Mathematics		
24 units minimum [1]		
MATH 41	Calculus (or AP Calculus)	5
MATH 42	Calculus (or AP Calculus)	5
CME 100/ENGR 154	Vector Calculus for Engineers	5
or MATH 51	Linear Algebra and Differential Calculus of Several Variables	
CME 102/ENGR 155A	Ordinary Differential Equations for Engineers	5
or MATH 53	Ordinary Differential Equations with Linear Algebra	
CME 106/ENGR 155C	Introduction to Probability and Statistics for Engineers (or STATS 110, STATS 116, CS 109)	4-5
or STATS 110	Statistical Methods in Engineering and the Physical Sciences	
or STATS 116	Theory of Probability	
or CS 109	Introduction to Probability for Computer Scientists	
Science		
19 units minimum		
PHYSICS 41	Mechanics (or AP Physics)	4
PHYSICS 43	Electricity and Magnetism (or AP Physics)	4
PHYSICS 45	Light and Heat	4
CHEM 31X	Chemical Principles Accelerated (or CHEM 31A +B, AP Chemistry)	5
Science elective [2]		3-5
Technology in Society (one course required)		
3 units minimum [3]		3-5
Engineering Fundamentals (three courses required)		
11 units minimum		
ENGR 30	Engineering Thermodynamics	3
ENGR 70A	Programming Methodology	5
Fundamentals Elective [4]		3-5
Engineering Depth		
28 units minimum		
AA 100	Introduction to Aeronautics and Astronautics	3
AA 190	Directed Research and Writing in Aero/Astro	3-5
ME 70	Introductory Fluids Engineering	4
ENGR 14	Intro to Solid Mechanics	4
ME 131A	Heat Transfer	3
ENGR 15	Dynamics	4
ME 161	Dynamic Systems, Vibrations and Control	3-4
or PHYSICS 110	Advanced Mechanics	
CEE 101A	Mechanics of Materials	4
or ME 80	Mechanics of Materials	
Aero/Astro Depth		
18 units minimum		
Engineering Electives (two courses required) [5]		6-10
See Course List AA-1 below for a list of options		
Depth Area I (two courses required) [6]		6-10
See Course List AA-2 below for a list of options		
Depth Area II (two courses required) [6]		6-10
See Course List AA-2 below for a list of options		
Total Units		**104-126**

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

1. It is recommended that the CME series (100, 102, 104) be taken rather than the MATH series (51, 52, 53). If students take the MATH series, it is recommended to take MATH 51M Introduction to MATLAB for Multivariable Mathematics, offered Autumn Quarter.
2. Courses that satisfy the Science elective are listed in Figure 3-2 in the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu.
3. Courses that satisfy the Technology in Society Requirement are listed in Figure 3-3 in the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu.
4. Courses that satisfy the Engineering Fundamentals elective are listed in Figure 3-4 in the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu. ENGR 70B or X (same as CS 106B or X) is not allowed to fulfill the third fundamentals requirement.
5. Courses that satisfy the Engineering Electives are listed in Figure AA-1 in the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu, as well as Course List AA-1 below.
6. Courses that satisfy the Depth Area choices are listed in Figure AA-2 in the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu, as well as Course List AA-2 below.

		Units
AA-1. Engineering Electives: Two Courses Required		
AA 250	Nanomaterials for Aerospace	3
ENGR 240	Introduction to Micro and Nano Electromechanical Systems	3
ME 210	Introduction to Mechatronics	4
ME 220	Introduction to Sensors	3-4
ME 227	Vehicle Dynamics and Control	3
ME 250	Internal Combustion Engines	3-5
ME 257	Turbine and Internal Combustion Engines	3
ME 260	Fuel Cell Science and Technology	3
ME 324	Precision Engineering	4
ME 331A	Advanced Dynamics & Computation	3
ME 331B	Advanced Dynamics, Simulation & Control	3
ME 345	Fatigue Design and Analysis	3
ME 348	Experimental Stress Analysis	3
ME 351A	Fluid Mechanics	3
ME 351B	Fluid Mechanics	3
CHEMENG 140	Micro and Nanoscale Fabrication Engineering	3
CS 107	Computer Organization and Systems	3-5
CS 110	Principles of Computer Systems	3-5
CS 140	Operating Systems and Systems Programming	3-4
CS 161	Design and Analysis of Algorithms	3-5
EE 102A	Signal Processing and Linear Systems I	4
EE 102B	Signal Processing and Linear Systems II	4
EE 101A	Circuits I	4
EE 101B	Circuits II	4
ENERGY 121	Fundamentals of Multiphase Flow	3
ENERGY 191	Optimization of Energy Systems	3-4
ENERGY 226	Thermal Recovery Methods	3
MATSCI 155	Nanomaterials Synthesis	4
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	3-4
MATSCI 197	Rate Processes in Materials	3-4
MATSCI 198	Mechanical Properties of Materials	3-4
PHYSICS 100	Introduction to Observational Astrophysics	4
* It is recommended that students review prerequisites for all courses.		

		Units
AA-2. Depth Area: Four Courses Required, Two From Each of Two Areas		
Dynamics and Controls		
ENGR 105	Feedback Control Design	3
ENGR 205	Introduction to Control Design Techniques	3
AA 203	Introduction to Optimal Control Theory	3
AA 222	Introduction to Multidisciplinary Design Optimization	3-4
AA 242A	Classical Dynamics	3
AA 271A	Dynamics and Control of Spacecraft and Aircraft	3
Systems Design		
AA 236A	Spacecraft Design	3-5
AA 236B	Spacecraft Design Laboratory	3-5
AA 241A	Introduction to Aircraft Design, Synthesis, and Analysis	3
AA 241B	Introduction to Aircraft Design, Synthesis, and Analysis	3
AA 284B	Propulsion System Design Laboratory	3
Fluids and CFD		
AA 200	Applied Aerodynamics	3
AA 201A	Fundamentals of Acoustics	3
AA 210A	Fundamentals of Compressible Flow	3
AA 214A/CME 207	Numerical Methods in Engineering and Applied Sciences	3
AA 283	Aircraft and Rocket Propulsion	3
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	4
ME 140	Advanced Thermal Systems	5
Structures		
AA 240A	Analysis of Structures	3
AA 240B	Analysis of Structures	3
AA 256	Mechanics of Composites	3
AA 280	Smart Structures	3
ME 335A	Finite Element Analysis	3
* It is recommended that students review prerequisites for all courses.		

Architectural Design (AD)

Completion of the undergraduate program in Architectural Design leads to the conferral of the Bachelor of Science in Engineering. The subplan "Architectural Design" appears on the transcript and on the diploma.

Mission of the Undergraduate Program in Architectural Design

The mission of the undergraduate program in Architectural Design is to develop students' ability to integrate engineering and architecture in ways that blend innovative architectural design with cutting-edge engineering technologies. Courses in the program combine hands-on architectural design studios with a wide variety of other courses. Students can choose from a broad mix of elective courses concerning energy conservation, sustainability, building systems, and structures, as well as design foundation and fine arts courses. In addition to preparing students for advanced studies in architecture and construction management, the program's math and science requirements prepare students well for graduate work in other fields such as civil and environmental engineering, law, and business.

Requirements

		Units
Mathematics and Science (36 units minimum) [1]		
Mathematics		
MATH 19	Calculus	3
MATH 20	Calculus	3
MATH 21	Calculus	4
Or the following sequence:		
MATH 41	Calculus	
MATH 42	Calculus	
CME 100	Vector Calculus for Engineers (Recommended)	5
One course in Statistics (required)		3-5
Science		
PHYSICS 41	Mechanics	4
Recommended:		
EARTHSYS 101	Energy and the Environment	

EARTHSYS 102	Renewable Energy Sources and Greener Energy Processes	
CEE 64	Air Pollution and Global Warming: History, Science, and Solutions	
CEE 70	Environmental Science and Technology	
CEE 101D	Computations in Civil and Environmental Engineering	
PHYSICS 23	Electricity, Magnetism, and Optics	
or PHYSICS 43	Electricity and Magnetism	
Or from School of Engineering approved list		
Technology in Society		
One course required, see Basic Requirement 4		3-5
Engineering Fundamentals		
Three courses minimum, see Basic Requirement 3		9-15
ENGR 14	Intro to Solid Mechanics	4
ENGR 60	Engineering Economy [2]	3
or CEE 146A	Engineering Economy	
AD Depth Core [3]		
CEE 31	Accessing Architecture Through Drawing	4
or CEE 31Q	Accessing Architecture Through Drawing	
CEE 100	Managing Sustainable Building Projects	4
CEE 120A	Building Information Modeling Workshop	2-4
CEE 130	Architectural Design: 3-D Modeling, Methodology, and Process	4
CEE 137B	Advanced Architecture Studio	5
ARTHIST 3	Introduction to World Architecture	5
Depth Options		12
See Note 3 for course options		
Depth Electives		
Elective units must be such that courses in ENGR Fundamentals, Core, Depth Options, and Depth Electives total at least 63 units. One of the following must be taken:		
CEE 131B	Financial Management of Sustainable Urban Systems	3
or CEE 32A	Psychology of Architecture	
or CEE 32B	Design Theory	
or CEE 32F	Light, Color, and Space	
or CEE 32R	American Architecture	
or CEE 32S	The Situated Workplace and Public Life	
or CEE 32T	Making and Remaking the Architect: Edward Durell Stone and Stanford	
or CEE 32U	Web of Apprenticeship	
or CEE 133F	Principles of Freehand Drawing	
or CEE 133G	Architectural History & Drawing in Eastern Europe	
or CEE 139	Design Portfolio Methods	
Total Units		**80-92**

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

1 School of Engineering approved list of math and science courses available in the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu.

2 CEE 146A, offered Autumn quarter, may be used in place of ENGR 60 for the second ENGR Fundamental.

3 Engineering depth options: Choose at least 12 units from the following courses: CEE 101A, CEE 101B, CEE 101C, CEE 156, CEE 172, CEE 172A, CEE 176A, CEE 180, CEE 181, CEE 182, CEE 183, CEE 226, CEE 241, OR CEE 242. Students should investigate any prerequisites for the listed courses and carefully plan course sequences with the AD director.
Electives:
- CEE 32A, CEE 32B, CEE 32D, CEE 32F, CEE 32G, CEE 32Q, CEE 32R, CEE 32S, CEE 32T, CEE 32U, CEE 101B, CEE 101C, CEE 120A, CEE 120B, CEE 120C, CEE 122A, CEE 122B, CEE 124, CEE 131A, CEE 131B, CEE 131C, CEE 132, CEE 134B, CEE 135A, CEE 139, CEE 172A, CEE 176A, CEE 180, CEE 181, CEE 182, CEE 183
- ENGR 50, ENGR 103, ENGR 131
- ME 10AX, ME 101, ME 110, ME 115A/B/C, ME 120, ME 203
- ARTSTUDI 13BX, ARTSTUDI 140, ARTSTUDI 145, ARTSTUDI 151, ARTSTUDI 160, ARTSTUDI 170, ARTSTUDI 171, ARTSTUDI 181
- ARTHIST 107A, ARTHIST 142, ARTHIST 143A, ARTHIST 188A
- FILMPROD 114
- TAPS 137
- URBANST 110, URBANST 113, URBANST 163, URBANST 171

Atmosphere/Energy (A/E)

Completion of the undergraduate program in Atmosphere/Energy leads to the conferral of the Bachelor of Science in Engineering. The subplan "Atmosphere/Energy" appears on the transcript and on the diploma.

Mission of the Undergraduate Program in Atmosphere/Energy

Atmosphere and energy are strongly linked: fossil-fuel energy use contributes to air pollution, global warming, and weather modification; and changes in the atmosphere feed back to renewable energy resources, including wind, solar, hydroelectric, and wave resources. The mission of the undergraduate program in Atmosphere/Energy (A/E) is to provide students with the fundamental background necessary to understand large- and local-scale climate, air pollution, and energy problems and solve them through clean, renewable, and efficient energy systems. To accomplish this goal, students learn in detail the causes and proposed solutions to the problems, and learn to evaluate whether the proposed solutions are truly beneficial. A/E students take courses in renewable energy resources, indoor and outdoor air pollution, energy efficient buildings, climate change, renewable energy and clean-vehicle technologies, weather and storm systems, energy technologies in developing countries, electric grids, and air quality management. The curriculum is flexible. Depending upon their area of interest, students may take in-depth courses in energy or atmosphere and focus either on science, technology, or policy. The major is designed to provide students with excellent preparation for careers in industry, government, and research; and for study in graduate school.

Requirements

		Units
Mathematics and Science (45 units minimum):		
Mathematics		23
23 units minimum, including at least one course from each group:		
Group A		
MATH 53	Ordinary Differential Equations with Linear Algebra	
CME 102	Ordinary Differential Equations for Engineers	
Group B		
CME 106	Introduction to Probability and Statistics for Engineers	
STATS 60	Introduction to Statistical Methods: Precalculus	
STATS 110	Statistical Methods in Engineering and the Physical Sciences	
Science		20

20 units minimum, including all of the following:		
PHYSICS 41	Mechanics	
PHYSICS 43	Electricity and Magnetism	
or PHYSICS 45	Light and Heat	
Select one of the following:		4
CHEM 31B	Chemical Principles II	
or CHEM 31X	Chemical Principles Accelerated	
CEE 70	Environmental Science and Technology [1]	
Technology in Society (1 course)		
MSE 197	Ethics, Technology, and Public Policy (WIM)	5
Engineering Fundamentals		
Three courses minimum, including the following:		
ENGR 25E	Energy: Chemical Transformations for Production, Storage, and Use	3
or ENGR 50E	Introduction to Materials Science, Energy Emphasis	
Plus one of the following courses, plus one elective (see Basic Requirement 3):		6-9
ENGR 10	Introduction to Engineering Analysis	
ENGR 30	Engineering Thermodynamics	
ENGR 60	Engineering Economy	
ENGR 70A	Programming Methodology	
Engineering Depth		
Required: [2]		
CEE 64	Air Pollution and Global Warming: History, Science, and Solutions (cannot also fulfill science requirement)	3
At least 36 units from the following with at least four courses from each group:		36
CEE 107A	Understanding Energy	
or CEE 107S	Energy Resources: Fuels and Tools	
Group A: Atmosphere		
AA 100	Introduction to Aeronautics and Astronautics	
CEE 63	Weather and Storms	
CEE 101N	Mechanics of Fluids	
or CEE 101B	Mechanics of Fluids	
or ME 70	Introductory Fluids Engineering	
CEE 164	Introduction to Physical Oceanography	
or ESS 146B	Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation	
CEE 172	Air Quality Management	
CEE 172A	Indoor Air Quality (given alt years)	
CEE 178	Introduction to Human Exposure Analysis	
EARTHSYS 37N	Climate Change: Science & Society	
or EARTHSYS 41N	The Global Warming Paradox	
EARTHSYS 57Q	Climate Change from the Past to the Future	
EARTHSYS 111	Biology and Global Change	
EARTHSYS 129	Geographic Impacts of Global Change: Mapping the Stories	
EARTHSYS 142	Remote Sensing of Land	
or EARTHSYS 144	Fundamentals of Geographic Information Science (GIS)	
EARTHSYS 146A	Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation (alt years)	
EARTHSYS 184	Climate and Agriculture (alt. years)	
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	
MSE 92Q	International Environmental Policy	
Group B: Energy		
APPPHYS 79N	Energy Options for the 21st Century	
AA 116Q	Electric Automobiles and Aircraft	
or EE 155	Green Electronics	
CEE 107F	Understanding Energy -- Field Trips	
CEE 107W	Understanding Energy -- Workshop	
CEE 109	Creating a Green Student Workforce to Help Implement Stanford's Sustainability Vision (alternate years)	
CEE 176A	Energy Efficient Buildings	
CEE 176B	Electric Power: Renewables and Efficiency	
CEE 177S	Design for a Sustainable World	
CHEMENG 35N	Renewable Energy for a Sustainable World	
EARTHSYS 46Q	Environmental Impact of Energy Systems: What are the Risks?	
EARTHSYS 101	Energy and the Environment	
EARTHSYS 102	Renewable Energy Sources and Greener Energy Processes	
ECON 17N	Energy, the Environment, and the Economy	
or OSPKYOTO 45	Japan's Energy-Environment Conundrum	
EE 151	Sustainable Energy Systems	
ENERGY 104	Sustainable Energy for 9 Billion	
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
ME 185	Electric Vehicle Design	
OSPSANTG 31	The Chilean Energy System: 30 Years of Market Reforms	
Total Units		**100-103**

1. Can count as a science requirement or Engineering Fundamental, but not both.
2. To fulfill the Writing in the Major (WIM) requirement take Technology in Society course MS&E 193W or MS&E 197. Alternative WIM Courses: CEE 100, EARTHSYS 200, HUMBIO 4B, or the combination of 2 units of CEE 199 with 1 unit of E199W.

Honors Program

The A/E honors program offers eligible students the opportunity to engage in guided original research, or project design, over the course of an academic year. Interested students must:

1. submit a 1-2 page letter applying to the honors program in A/E. The letter must describe the problem to be investigates. Students must obtain signatures from the current primary adviser and the proposed honors adviser, if different, and submit the letter to the student services office in the Department of Civil and Environmental Engineering

(CEE). The application must include an unofficial Stanford transcript. Applications must be received in the fourth quarter prior to graduation. It is recommended that a prospective student meet with the proposed honors adviser well in advance of submitting an application.
2. maintain a GPA of at least 3.5.
3. complete an honors thesis or project over a period of three quarters. The typical length of the written report is 15-20 pages. The deadline for submission of the report is decided by the honors adviser, but should be no later than the end of the third week in May.
4. present their thesis or project be read and evaluated by the honors adviser and one other reader. It is the student's responsibility to obtain both the adviser and the reader. At least one of the two must be a member of the Academic Council in the School of Engineering.
5. present the completed work in an appropriate forum such as in the same session as honors theses are presented in the department of the adviser. All honors programs require some public presentation of the thesis or project.
6. take up to 10 units of CEE 199H Undergraduate Honors Thesis toward the thesis (optional). Students must take ENGR 202S Writing: Special Projects or its equivalent. Units for ENGR 202S are beyond those required for the A/E major.
7. submit wo copies of the signed thesis to the CEE student services office no later than two weeks before the end of the graduation quarter.

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

Bioengineering (BioE)

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

Mission of the Undergraduate Program in Bioengineering

The Stanford Bioengineering (BioE) major enables students to combine engineering and the life sciences in ways that advance scientific discovery, healthcare and medicine, manufacturing, environmental quality, culture, education, and policy. Students who major in BioE earn a fundamental engineering degree for which the raw materials, underlying basic sciences, fundamental toolkit, and future frontiers are all defined by the unique properties of living systems.

Students will complete engineering fundamentals courses, including an introduction to BioE and computer programming. A series of core BioE classes beginning in the second year leads to a student-selected depth area and a senior capstone design project. The department also organizes a summer Research Experience for Undergraduates (REU) program (http://bioengineering.stanford.edu/education/REU.html). BioE graduates are well prepared to pursue careers and lead projects in research, medicine, business, law, and policy.

Requirements

		Units
Mathematics [1]		
28 units minimum required, see Basic Requirement 1)		
MATH 41 & MATH 42	Calculus and Calculus (or AP Calculus)	10
Select one of the following:		
CME 100	Vector Calculus for Engineers (Recommended)	5
or MATH 51	Linear Algebra and Differential Calculus of Several Variables	
Select one of the following:		
CME 102	Ordinary Differential Equations for Engineers (Recommended)	5
or MATH 53	Ordinary Differential Equations with Linear Algebra	
Select one of the following:		
CME 104	Linear Algebra and Partial Differential Equations for Engineers (Recommended)	5
or MATH 52	Integral Calculus of Several Variables	
CME 106	Introduction to Probability and Statistics for Engineers (Recommended)	3-5
or STATS 110	Statistical Methods in Engineering and the Physical Sciences	
or STATS 141	Biostatistics	
Science [2]		
28 units minimum:		
CHEM 31X	Chemical Principles Accelerated	5-10
or CHEM 31A & CHEM 31B	Chemical Principles I and Chemical Principles II	
CHEM 33	Structure and Reactivity	5
BIO 41	Genetics, Biochemistry, and Molecular Biology	5
BIO 42	Cell Biology and Animal Physiology	5
PHYSICS 41	Mechanics	4
PHYSICS 43	Electricity and Magnetism	4
Technology in Society		
One course required; see Basic Requirement 4		
BIOE 131	Ethics in Bioengineering (WIM)	3
Engineering Fundamentals		
ENGR 70A	Programming Methodology (same as CS 106A)	5
ENGR 80	Introduction to Bioengineering (Engineering Living Matter)	4
Fundamentals Elective; see UGHB Fig. 3-4 for approved course list; may not use ENGR 70B or ENGR 70X		3-5
Bioengineering Core		
BIOE 41	Physical Biology of Macromolecules	4
BIOE 42	Physical Biology of Cells	4
BIOE 44	Fundamentals for Engineering Biology Lab	4
BIOE 51	Anatomy for Bioengineers	4
BIOE 101	Systems Biology	3
BIOE 103	Systems Physiology and Design	4
BIOE 123	Optics and Devices Lab	4
BIOE 141A	Senior Capstone Design I	4
BIOE 141B	Senior Capstone Design II	4
Bioengineering Depth Electives		
Four courses, minimum 12 units:		12
BIOE 115	Computational Modeling of Microbial Communities	
BIOE 122	Biosecurity and Bioterrorism Response	
BIOE 201C	Diagnostic Devices Lab	
BIOE 211	Biophysics of Multi-cellular Systems and Amorphous Computing	
BIOE 212	Introduction to Biomedical Informatics Research Methodology	
BIOE 214	Representations and Algorithms for Computational Molecular Biology	
BIOE 220	Introduction to Imaging and Image-based Human Anatomy	
BIOE 221	Physics and Engineering of Radionuclide Imaging	
BIOE 222	Instrumentation and Applications for Multi-modality Molecular Imaging of Living Subjects	
BIOE 223	Physics and Engineering of X-Ray Computed Tomography	

BIOE 224	Probes and Applications for Multi-modality Molecular Imaging of Living Subjects
BIOE 227	Functional MRI Methods
BIOE 231	Protein Engineering
BIOE 244	Advanced Frameworks and Approaches for Engineering Integrated Genetic Systems
BIOE 253	Science and Technology Policy
BIOE 260	Tissue Engineering
BIOE 281	Biomechanics of Movement
BIOE 287	Introduction to Physiology and Biomechanics of Hearing
BIOE 291	Principles and Practice of Optogenetics for Optical Control of Biological Tissues
Total Units	**118-127**

1 It is strongly recommended that CME 100 Vector Calculus for Engineers, CME 102 Ordinary Differential Equations for Engineers, and CME 104 Linear Algebra and Partial Differential Equations for Engineers) be taken rather than MATH 51 Linear Algebra and Differential Calculus of Several Variables, MATH 52 Integral Calculus of Several Variables, and MATH 53 Ordinary Differential Equations with Linear Algebra. CME 106 Introduction to Probability and Statistics for Engineers utilizes MATLAB, a powerful technical computing program, and should be taken rather than STATS 110 Statistical Methods in Engineering and the Physical Sciences or STATS 141 Biostatistics. If you are taking the MATH 50 series, it is strongly recommended to take MATH 51M Introduction to MATLAB or CME 192 Introduction to MATLAB.

2 Science must include both Chemistry (CHEM 31A Chemical Principles I and CHEM 31B Chemical Principles II; or CHEM 31X Chemical Principles Accelerated) and calculus-based Physics, with two quarters of course work in each, in addition to two courses of BIO core. CHEM 31A Chemical Principles I and CHEM 31B Chemical Principles II are considered one course even though given over two quarters.

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu). Students pursuing a premed program need to take additional courses; see the UGHB, BioE Premed 4-Year Plan.

Honors Program

The School of Engineering offers a program leading to a Bachelor of Science in Bioengineering with Honors (BIOE-BSH). This program provides the opportunity for qualified BioE majors to conduct independent research at an advanced level with a faculty research adviser and documented in an honors thesis.

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

1. Declare the honors program in Axess (BIOE-BSH).
2. Maintain an overall grade point average (GPA) of at least 3.5 as calculated on the unofficial transcript.
3. Complete at least two quarters of research with a minimum of nine units of BIOE 191 Bioengineering Problems and Experimental Investigation or BIOE 191X Out-of-Department Advanced Research Laboratory in Bioengineering for a letter grade; up to three units may be used towards the bioengineering depth elective requirements.
4. Submit a completed thesis draft to the honors adviser and second reader by the first week of Spring Quarter. Further revisions and final endorsement are to be finished by the second Monday in May, when two signed bound copies plus one PC-compatible CD-ROM are to be submitted to the student services officer.
5. Attend the Bioengineering Honors Symposium at the end of Spring Quarter and give a poster or oral presentation, or present in another approved suitable forum.

For more information and application instructions, see the department's undergraduate site (http://bioengineering.stanford.edu/education/bioe-honors-instructions-v.2.pdf).

Biomechanical Engineering (BME)

Completion of the undergraduate program in Biomechanical Engineering leads to the conferral of the Bachelor of Science in Engineering. The subplan "Biomechanical Engineering" appears on the transcript and on the diploma.

Mission of the Undergraduate Program in Biomechanical Engineering

The mission of the undergraduate program in Biomechanical Engineering is to help students address health science challenges by applying engineering mechanics and design to the fields of biology and medicine. The program is interdisciplinary in nature, integrating engineering course work with biology and clinical medicine. Research and teaching in this discipline focus primarily on neuromuscular, musculoskeletal, cardiovascular, and cell and tissue biomechanics. This major prepares students for graduate studies in bioengineering, medicine or related areas.

Requirements

		Units
Mathematics		21
21 units minimum; see Basic Requirement 1		
Science (22 units Minimum) [1]		
CHEM 31X	Chemical Principles Accelerated (or CHEM 31A +B)	5
CHEM 33	Structure and Reactivity	5
PHYSICS 41	Mechanics	4
BIO 44X	Core Molecular Biology Laboratory	5
Biology or Human Biology A/B core courses		10
Technology in Society		
One course required, see Basic Requirement 4		3-5
Engineering Topics (Engineering Science and Design)		
Engineering Fundamentals (minimum three courses; see Basic Requirement 3):		
ENGR 14	Intro to Solid Mechanics	4
ENGR 25B	Biotechnology	3
or ENGR 80	Introduction to Bioengineering (Engineering Living Matter)	
Fundamentals Elective		3-5
Engineering Depth		
ENGR 15	Dynamics	4
ENGR 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	4
ME 80	Mechanics of Materials	4
ME 389	Biomechanical Research Symposium [2]	1
Options to complete the ME depth sequence (3 courses, minimum 9 units):		9
ENGR 105	Feedback Control Design	
ME 101	Visual Thinking	
ME 112	Mechanical Systems Design [3]	

ME 113	Mechanical Engineering Design	
ME 131A	Heat Transfer [3]	
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	
ME 140	Advanced Thermal Systems [3]	
ME 161	Dynamic Systems, Vibrations and Control	
ME 203	Design and Manufacturing	
ME 210	Introduction to Mechatronics	
ME 220	Introduction to Sensors	
Options to complete the BME depth sequence (3 courses, minimum 9 units) and WIM: [3]		9
BIOE 260	Tissue Engineering	
ME 239	Mechanics of the Cell	
ME 266	Introduction to Physiology and Biomechanics of Hearing	
ME 280	Skeletal Development and Evolution	
ME 281	Biomechanics of Movement	
ME 283	Tissue Mechanics and Mechanobiology	
ME 287	Mechanics of Biological Tissues	
ME 294L		
ME 328	Medical Robotics (with permission of instructor)	
Total Units		**97-101**

1. Science must include both Chemistry and Physics with one year of course work (3 courses) in at least one, two courses of HUMBIO core or BIO core, and CHEM 31A and B or X, *or* ENGR 31. CHEM 31A and B are considered one course even though given over two quarters.
2. If ME 389 is not offered, other options include BIOE 393, ME 571, or course by petition.
3. There are two options for fulfilling the WIM requirement. The first option is to complete one of ME112, ME131A, or ME140 (ME 131A must be taken for 5 units to fulfill WIM). The second option is to perform engineering research over the summer or during the academic year and enroll in 3 units of ENGR 199W “Writing of Original Research for Engineers,” (preferably during the time you are performing research or the following quarter) to write a technical report on your research. This second option requires an agreement with your faculty research supervisor.

Honors Program

The School of Engineering offers a program leading to a Bachelor of Science in Engineering: Biomechanical Engineering with Honors. This program provides an opportunity for qualified BME majors to conduct independent study and research related to biomechanical engineering at an advanced level with a faculty mentor.

Honors Criteria:

- GPA of 3.5 or higher in the major
- Arrangement with an ME faculty member (or a faculty member from another department who is approved by the BME Undergraduate Program Director) who agrees to serve as the honors adviser, plus a second faculty member who reads and approves the thesis. The honors adviser must be a member of the Academic Council in the School of Engineering.
- Applications are subject to the review and final approval by the BME Undergraduate Program Director. Applicants and thesis advisers receive written notification when a decision has been made. Submit application documents to the student services office, Building 530, room 125.
- An application consists of
    - One page written statement describing the research topic
    - Unofficial Stanford transcript
    - Signature of thesis adviser and thesis reader agreeing to serve on the committee
    - Deadline: No later than the second week of the Autumn Quarter of the senior year
- In order to graduate with honors:
    - Declare ENGR-BSH (Honors) program in Axess
    - Maintain 3.5 GPA
    - Submit a completed thesis draft to the adviser and reader by April 1
    - Present the thesis synopsis at the Mechanical Engineering Poster Session held in April
- Further revisions and a final endorsement by the adviser and reader are to be completed by May 15 when two bound copies are to be submitted to the Mechanical Engineering student services office.

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

Biomedical Computation (BMC)

Completion of the undergraduate program in Biomedical Computation leads to the conferral of the Bachelor of Science in Engineering. The subplan "Biomedical Computation" appears on the transcript and on the diploma.

Mission of the Undergraduate Program in Biomedical Computation

As biology and medical science enter the 21st century, the importance of computational methods continues to increase dramatically. These methods span the analysis of biomedical data, the construction of computational models for biological systems, and the design of computer systems that help biologists and physicians create and administer treatments to patients. The Biomedical Computation major prepares students to work at the cutting edge of this interface between computer science, biology, and medicine. Students begin their journey by gaining a solid fundamental understanding of the underlying biological and computational disciplines. They learn techniques in informatics and simulation and their countless applications in understanding and analyzing biology at all levels, from individual molecules in cells to entire organs, organisms, and populations. Students then focus their efforts pm a depth area of their choice, and participate in a substantial research project with a Stanford faculty member. Upon graduation, students are prepared to enter a wide range of cutting-edge fields in both academia and industry.

Requirements

		Units
Mathematics		
21 unit minimum, see Basic Requirement 1		
MATH 41	Calculus	5
MATH 42	Calculus	5
STATS 116	Theory of Probability [1]	3-5
CS 103	Mathematical Foundations of Computing	3-5
Science		
17 units minimum, see Basic Requirement 2		
PHYSICS 41	Mechanics	4
CHEM 31X	Chemical Principles Accelerated	5
CHEM 33	Structure and Reactivity	5
BIO 41	Genetics, Biochemistry, and Molecular Biology	5
or HUMBIO 2A	Genetics, Evolution, and Ecology	

BIO 42	Cell Biology and Animal Physiology	5
or HUMBIO 3A	Cell and Developmental Biology	
BIO 43	Plant Biology, Evolution, and Ecology	5
or HUMBIO 4A	The Human Organism	
Engineering Fundamentals		
CS 106B	Programming Abstractions	3-5
or CS 106X	Programming Abstractions (Accelerated)	
For the second required course, see concentrations		
Technology in Society		
One course required, see Basic Requirement 4		3-5
Engineering		
CS 107	Computer Organization and Systems	3-5
CS 161	Design and Analysis of Algorithms	3-5
Select one of the following:		3
CS 270	Modeling Biomedical Systems: Ontology, Terminology, Problem Solving	
CS 273A	A Computational Tour of the Human Genome	
CS 274	Representations and Algorithms for Computational Molecular Biology	
CS 275	Translational Bioinformatics	
CS 279	Computational Biology: Structure and Organization of Biomolecules and Cells	
Research: 6 units of biomedical computation research in any department [2,3]		6
Engineering Depth Concentration (select one of the following concentrations): [7]		
Cellular/Molecular Concentration		
Mathematics: Select one of the following:		
CME 100	Vector Calculus for Engineers	
STATS 141	Biostatistics	
MATH 51	Linear Algebra and Differential Calculus of Several Variables	
One additional Engineering Fundamental [4]		
Biology (four courses):		
BIO 129A	Cellular Dynamics I: Cell Motility and Adhesion	
BIO 129B	Cellular Dynamics II: Building a Cell	
BIO 188	Biochemistry I (or CHEM 135 or CHEM 171)	
Informatics Electives (two courses) [5,6]		
Simulation Electives (two courses) [5, 6]		
Simulation, Informatics, or Cell/Mol Elective (one course) [5,6]		
Informatics Concentration		
Mathematics: Select one of the following:		
STATS 141	Biostatistics	
STATS 203	Introduction to Regression Models and Analysis of Variance	
STATS 205	Introduction to Nonparametric Statistics	
STATS 215	Statistical Models in Biology	
One additional Engineering Fundamental [4]		
Informatics Core (three courses):		
CS 145	Introduction to Databases	
or CS 147	Introduction to Human-Computer Interaction Design	
CS 221	Artificial Intelligence: Principles and Techniques	
or CS 228	Probabilistic Graphical Models: Principles and Techniques	
or CS 229	Machine Learning	
One additional course from the previous two lines		
Informatics Electives (three courses) [5,6]		
Cellular Electives (two courses) [5,6]		
Organs Electives (two courses) [5,6]		6-10
Organs/Organisms Concentration		
Mathematics (select one of the following):		
CME 100	Vector Calculus for Engineers	
STATS 141	Biostatistics	
MATH 51	Linear Algebra and Differential Calculus of Several Variables	
One additional Engineering Fundamental [4]		
Biology (two courses):		
BIO 112	Human Physiology	
BIO 188	Biochemistry I	
or BIOE 220	Introduction to Imaging and Image-based Human Anatomy	
Two additional Organs Electives [5,6]		
Simulation Electives (two courses) [5,6]		
Informatics Electives (two courses) [5,6]		
Simulation, Informatics, or Organs Elective (one course) [5,6]		
Simulation Concentration		
Mathematics:		
CME 100	Vector Calculus for Engineers	
or MATH 51	Linear Algebra and Differential Calculus of Several Variables	
Engineering Fundamentals:		
ENGR 30	Engineering Thermodynamics	
Simulation Core:		
CME 102	Ordinary Differential Equations for Engineers	5
or MATH 53	Ordinary Differential Equations with Linear Algebra	
ENGR 80	Introduction to Bioengineering (Engineering Living Matter)	4
BIOE 101	Systems Biology	3
BIOE 103	Systems Physiology and Design	4
Simulation Electives (two courses) [5, 6]		
Cellular Elective (one course) [5,6]		
Organs Elective (one course) [5,6]		
Simulation, Cellular, or Organs Elective (two courses) [5,6]		
Total Units		**88-104**

1. CS 109 Introduction to Probability for Computer Scientists, MSE 120 Probabilistic Analysis, MSE 220 Probabilistic Analysis, EE 178 Probabilistic Systems Analysis, and CME 106 Introduction to Probability and Statistics for Engineers are acceptable substitutes for STATS 116 Theory of Probability.
2. Research projects require pre-approval of BMC Coordinators
3. Research units taken as CS 191W Writing Intensive Senior Project or in conjunction with ENGR 199W Writing of Original Research for Engineers fulfill the Writing in the Major (WIM) requirement. CS 272 Introduction to Biomedical Informatics Research Methodology, which does not have to be taken in conjunction with research, also fulfills the WIM requirement.
4. One 3-5 unit course required; CS 106A Programming Methodology may not be used. See Fundamentals list in Handbook for Undergraduate Engineering Programs.
5. The list of electives is continually updated to include all applicable courses. For the current list of electives, see http://bmc.stanford.edu.

6 A course may only be counted towards one elective or core requirement; it may not be double-counted.

7 A total of 40 Engineering units must be taken. The core classes only provide 27 Engineering units, so the remaining units must be taken from within the electives.

Honors Program

The Biomedical Computation program offers an honors option for qualified students, resulting in a B.S. with Honors degree in Engineering (ENGR-BSH, Biomedical Computation). An honors project is meant to be a substantial research project during the later part of a student's undergraduate career, culminating in a final written and oral presentation describing the student's project and its significance. There is no limit to the number of majors who can graduate with honors; any BMC major who is interested and meets the qualifications is considered.

1. Students apply by submitting a 1-2 page proposal describing the problem the student has chosen to investigate, its significance, and the student's research plan. This plan must be endorsed by the student's research and academic advisers, one of whom must be a member of the Academic Council. In making its decision, the department evaluates the overall scope and significance of the student's proposed work.
2. Students must maintain a 3.5 GPA.
3. Students must complete three quarters of research. All three quarters must be on the same project with the same adviser. A Summer Quarter counts as one quarter of research.
   - Ideally, funding should not be obtained through summer research college sources, but rather through the UAR's Student Grants Program (http://exploredegrees.stanford.edu/schoolofengineering/%20http://studentgrants.stanford.edu). In no case can the same work be double-paid by two sources.
4. Students must complete a substantial write-up of the research in the format of a publishable research paper. This research paper is expected to be approximately 15-20 pages and must be approved by the student's research adviser and by a second reader.
5. As the culmination of the honors project, each student presents the results in a public forum. This can either be in the honors presentation venue of the home department of the student's adviser, or in a suitable alternate venue.

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

Chemical Engineering (CHE)

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

Mission of the Undergraduate Program in Chemical Engineering

Chemical engineers are responsible for the conception and design of processes for the purpose of production, transformation, and transportation of materials. This activity begins with experimentation in the laboratory and is followed by implementation of the technology in full-scale production. The mission of the undergraduate program in Chemical Engineering is to develop students' understanding of the core scientific, mathematical, and engineering principles that serve as the foundation underlying these technological processes. The program's core mission is reflected in its curriculum which is built on a foundation in the sciences of chemistry, physics, and biology. Course work includes the study of applied mathematics, material and energy balances, thermodynamics, fluid mechanics, energy and mass transfer, separations technologies, chemical reaction kinetics and reactor design, and process design. The program provides students with excellent preparation for careers in the corporate sector and government, or for graduate study.

Requirements*

		Units
Mathematics [1]		
MATH 41	Calculus	5
MATH 42	Calculus	5
Select one of the following:		5-10
CME 100	Vector Calculus for Engineers	
MATH 51 & MATH 52	Linear Algebra and Differential Calculus of Several Variables and Integral Calculus of Several Variables	
Select one of the following:		5
CME 102	Ordinary Differential Equations for Engineers	
or MATH 53	Ordinary Differential Equations with Linear Algebra	
Select one of the following:		4-5
CME 104	Linear Algebra and Partial Differential Equations for Engineers	
or CME 106	Introduction to Probability and Statistics for Engineers	
Science [1]		
CHEM 31X	Chemical Principles Accelerated	5
CHEM 33	Structure and Reactivity	5
CHEM 35	Synthetic and Physical Organic Chemistry	5
PHYSICS 41	Mechanics	4
PHYSICS 43	Electricity and Magnetism	4
CHEM 131	Organic Polyfunctional Compounds	3
Technology in Society		
One course required, see Basic Requirement 4		3-5
Engineering Fundamentals		
Three courses minimum; see Basic Requirement 3		
ENGR/ CHEMENG 20	Introduction to Chemical Engineering	3
Fundamentals Elective from another School of Engineering department		3-5
See the UGHB for a list of courses.		
Select one of the following:		3
ENGR 25B	Biotechnology (same as CHEMENG 25B)	
ENGR 25E	Energy: Chemical Transformations for Production, Storage, and Use (same as CHEMENG 25E)	
Chemical Engineering Depth		
Minimum 68 Engineering Science and Design units; see Basic Requirement 5		
CHEMENG 10	The Chemical Engineering Profession	1
CHEMENG 100	Chemical Process Modeling, Dynamics, and Control	3
CHEMENG 110	Equilibrium Thermodynamics	3
CHEMENG 120A	Fluid Mechanics	4
CHEMENG 120B	Energy and Mass Transport	4
CHEMENG 130	Separation Processes	3
CHEMENG 150	Biochemical Engineering	3
CHEMENG 170	Kinetics and Reactor Design	3
CHEMENG 180	Chemical Engineering Plant Design	4
CHEMENG 181	Biochemistry I	3
CHEMENG 185A	Chemical Engineering Laboratory A (WIM)	4
CHEMENG 185B	Chemical Engineering Laboratory B	4
CHEM 171	Physical Chemistry I	3
CHEM 173	Physical Chemistry II	3
CHEM 175	Physical Chemistry III	3

Select four of the following: [2,3]		12
CHEMENG 140	Micro and Nanoscale Fabrication Engineering	
CHEMENG 142	Basic Principles of Heterogeneous Catalysis with Applications in Energy Transformations	
CHEMENG 160	Polymer Science and Engineering	
CHEMENG 162	Polymers for Clean Energy and Water	
CHEMENG 174	Environmental Microbiology I	
CHEMENG 183	Biochemistry II	
CHEMENG 196	Creating New Ventures in Engineering and Science-based Industries	
Total Units		**122-132**

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

1 Unit count is higher if program includes one of more of the following: MATH 51 and MATH 52 in lieu of CME 100; or CHEM 31A and CHEM 31B in lieu of CHEM 31X.

2 Any two acceptable except combining 160 and 162.

3 Students may substitute two of the depth electives with two other science and engineering 3-unit lecture courses. See UGHB for additional details.

Civil Engineering (CE)

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

Mission of the Undergraduate Program in Civil Engineering

The mission of the undergraduate program in Civil Engineering is to provide students with the principles of engineering and the methodologies necessary for civil engineering practice. This pre-professional program balances the fundamentals common to many specialties in civil engineering and allows for concentration in structures and construction or environmental and water studies. Students in the major learn to apply knowledge of mathematics, science, and civil engineering to conduct experiments, design structures and systems to creatively solve engineering problems, and communicate their ideas effectively. The curriculum includes course work in structural, construction, and environmental engineering. The major prepares students for careers in consulting, industry and government, as well as for graduate studies in engineering.

Requirements

		Units
Mathematics and Science		45
45 units minimum; see Basic Requirements 1 and 2 [1]		
Technology in Society		
One course; see Basic Requirement 4 [2]		3-5
Engineering Fundamentals		
Three courses minimum, see Basic Requirement 3		
ENGR 14	Intro to Solid Mechanics	4
ENGR 90/CEE 70	Environmental Science and Technology	3
Fundamentals Elective		3-5
Engineering Depth		
Minimum of 68 Engineering Fundamentals plus Engineering Depth; see Basic Requirement 5		
CEE 100	Managing Sustainable Building Projects [3]	4
CEE 101A	Mechanics of Materials	4
CEE 101B	Mechanics of Fluids (or CEE 101N)	4
CEE 101C	Geotechnical Engineering	4
CEE 146A	Engineering Economy	3
Specialty courses in either:		36-39
Environmental and Water Studies (see below)		
Structures and Construction (see below)		
Other School of Engineering Electives		3-0
Total Units		**116-120**

1 Mathematics must include CME 100 Vector Calculus for Engineers and CME 102 Ordinary Differential Equations for Engineers (or Math 51 Linear Algebra and Differential Calculus of Several Variables and MATH 53 Ordinary Differential Equations with Linear Algebra) and a Statistics course. Science must include Physics 41 Mechanics; either ENGR 31 Chemical Principles with Application to Nanoscale Science and Technology, CHEM31A Chemical Principles I or CHEM 31X Chemical Principles; two additional quarters in either chemistry or physics, and GS 1A Introduction to Geology: The Physical Science of the Earth (or GS 1B or 1C); for students in the Environmental and Water Studies track, the additional chemistry or physics must include CHEM 33; for students in the Structures and Construction track, it must include PHYSICS 43 or 45. Please note that the only quarter GS 1A is offered for AY 2015-16 is Spring Quarter.

2 Chosen TiS class must specifically include an ethics component, as indicated in Figure 3-3 in the Engineering Undergraduate Handbook (http://web.stanford.edu/group/ughb/cgi-bin/handbook/index.php/Handbooks)

3 CEE 100 meets the Writing in the Major (WIM) requirement

Environmental and Water Studies Focus

		Units
ENGR 30	Engineering Thermodynamics [1]	3
CEE 101D	Computations in Civil and Environmental Engineering (or CEE 101S) [2]	3
CEE 160	Mechanics of Fluids Laboratory (req'd only if CEE 101B is taken)	2
CEE 161A	Rivers, Streams, and Canals	3-4
CEE 166A	Watersheds and Wetlands	3
CEE 166B	Floods and Droughts, Dams and Aqueducts	3
CEE 171	Environmental Planning Methods	3
CEE 172	Air Quality Management	3
CEE 177	Aquatic Chemistry and Biology	4
CEE 179A	Water Chemistry Laboratory	3
CEE 179C	Environmental Engineering Design	5
(or CEE 169) Capstone design experience course		
Remaining specialty units from:		
CEE 63	Weather and Storms [2]	3
CEE 64	Air Pollution and Global Warming: History, Science, and Solutions [2]	3
CEE 107A	Understanding Energy	3
CEE 107F	Understanding Energy -- Field Trips	1
CEE 107W	Understanding Energy -- Workshop	1

CEE 109	Creating a Green Student Workforce to Help Implement Stanford's Sustainability Vision	2
CEE 155	Introduction to Sensing Networks for CEE	4
CEE 164	Introduction to Physical Oceanography	4
CEE 165C	Water Resources Management	3
CEE 166D	Water Resources and Water Hazards Field Trips	2
CEE 172A	Indoor Air Quality	2-3
CEE 174A	Providing Safe Water for the Developing and Developed World	3
CEE 174B	Wastewater Treatment: From Disposal to Resource Recovery	3
CEE 176A	Energy Efficient Buildings	3-4
CEE 176B	Electric Power: Renewables and Efficiency	3-4
CEE 178	Introduction to Human Exposure Analysis	3
CEE 199	Undergraduate Research in Civil and Environmental Engineering	1-4

Structures and Construction Focus

		Units
CEE 102	Legal Principles in Design, Construction, and Project Delivery	3
CEE 156	Building Systems	4
CEE 180	Structural Analysis	4
CEE 181	Design of Steel Structures	4
CEE 182	Design of Reinforced Concrete Structures	4
CEE 183	Integrated Civil Engineering Design Project	4
Select one of the following:		4
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis	
ENGR 50E	Introduction to Materials Science, Energy Emphasis	
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis	
Remaining specialty units from:		
ENGR 15	Dynamics	4
CME 104	Linear Algebra and Partial Differential Equations for Engineers	5
CEE 101D	Computations in Civil and Environmental Engineering (or CEE 101S)	3
CEE 112A	Industry Applications of Virtual Design & Construction	2-4
CEE 112B	Industry Applications of Virtual Design & Construction	2-4
CEE 122A	Computer Integrated Architecture/Engineering/Construction	2
CEE 122B	Computer Integrated A/E/C	2
CEE 131A Professional Practice: Mixed Use Design in an Urban Setting (not given AY 2015-16)		
CEE 131B	Financial Management of Sustainable Urban Systems	3
CEE 141A	Infrastructure Project Development	3
CEE 141B	Infrastructure Project Delivery	3
CEE 151	Negotiation	3
CEE 155	Introduction to Sensing Networks for CEE	4
CEE 160	Mechanics of Fluids Laboratory	2
CEE 161A	Rivers, Streams, and Canals	3-4
CEE 171	Environmental Planning Methods	3
CEE 176A	Energy Efficient Buildings	3-4
CEE 176B	Electric Power: Renewables and Efficiency	3-4
CEE 195	Fundamentals of Structural Geology	3
CEE 196	Engineering Geology and Global Change	3
CEE 199	Undergraduate Research in Civil and Environmental Engineering	1-4
CEE 203	Probabilistic Models in Civil Engineering	3-4
One of the following can also count as remaining specialty units.		3-4
CEE 120A	Building Information Modeling Workshop (or CEE 120S or CEE 120B)	2-4
CEE 130	Architectural Design: 3-D Modeling, Methodology, and Process	
CEE 131A	Professional Practice: Mixed-Use Design in an Urban Setting	
CEE 134B	Intermediate Arch Studio	

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

Computer Science (CS)

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

Mission of the Undergraduate Program in Computer Science

The mission of the undergraduate program in Computer Science is to develop students' breadth of knowledge across the subject areas of computer sciences, including their ability to apply the defining processes of computer science theory, abstraction, design, and implementation to solve problems in the discipline. Students take a set of core courses. After learning the essential programming techniques and the mathematical foundations of computer science, students take courses in areas such as programming techniques, automata and complexity theory, systems programming, computer architecture, analysis of algorithms, artificial intelligence, and applications. The program prepares students for careers in government, law, and the corporate sector, and for graduate study.

Requirements

Mathematics (26 units minimum)—

CS 103	Mathematical Foundations of Computing [1]	5
CS 109	Introduction to Probability for Computer Scientists [2]	5
MATH 41 & MATH 42	Calculus and Calculus [3]	10
Plus two electives [2]		

Science (11 units minimum)—

PHYSICS 41	Mechanics	4
PHYSICS 43	Electricity and Magnetism	4
Science elective [5]		3

Technology in Society (3-5 units)—

One course; see Basic Requirement 4

Engineering Fundamentals (13 units minimum; see Basic Requirement 3)—

CS 106B	Programming Abstractions	5
or CS 106X	Programming Abstractions (Accelerated)	
ENGR 40	Introductory Electronics [4]	5

or ENGR 40A or 40M*		
Fundamentals Elective (may not be 70A, B, or X)		3-5
*Students who take ENGR 40A or 40M for fewer than 5 units are required to take 1-2 additional units of ENGR Fundamentals (13 units minimum), or 1-2 additional units of Depth (27 units minimum for track and elective courses).		

Writing in the Major—

Select one of the following:		
CS 181W	Computers, Ethics, and Public Policy	
CS 191W	Writing Intensive Senior Project	
CS 194W	Software Project	
CS 210B	Software Project Experience with Corporate Partners	
CS 294W	Writing Intensive Research Project in Computer Science	

Computer Science Core (15 units)—

CS 107	Computer Organization and Systems	5
or CS 107E	Computer Systems from the Ground Up	
CS 110	Principles of Computer Systems	5
CS 161	Design and Analysis of Algorithms	5

Computer Science Depth B.S.

Choose one of the following ten CS degree tracks (a track must consist of at least 25 units and 7 classes):

Artificial Intelligence Track—

		Units
CS 221	Artificial Intelligence: Principles and Techniques	4
Select two of the following:		6-8
CS 223A	Introduction to Robotics	
CS 224M	Multi-Agent Systems	
CS 224N	Natural Language Processing	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 229	Machine Learning	
CS 131	Computer Vision: Foundations and Applications	
or CS 231A	Computer Vision: From 3D Reconstruction to Recognition	
One additional course from the list above or the following:		3-4
CS 124	From Languages to Information	
CS 205A	Mathematical Methods for Robotics, Vision, and Graphics	
CS 222		
CS 224S	Spoken Language Processing	
CS 224U	Natural Language Understanding	
CS 224W	Social Information and Network Analysis	
CS 225A	Experimental Robotics	
CS 225B	Robot Programming Laboratory	
CS 227B	General Game Playing	
CS 231A	Computer Vision: From 3D Reconstruction to Recognition (If not taken for track requirement B)	
CS 231B	The Cutting Edge of Computer Vision	
CS 231M	Mobile Computer Vision	
CS 231N	Convolutional Neural Networks for Visual Recognition	
CS 262	Computational Genomics	
CS 276	Information Retrieval and Web Search	
CS 277	Experimental Haptics	
CS 279	Computational Biology: Structure and Organization of Biomolecules and Cells	
CS 329	Topics in Artificial Intelligence (with adviser consent)	
CS 331A	Advanced Reading in Computer Vision	
CS 371	Computational Biology in Four Dimensions	
CS 374	Algorithms in Biology	
CS 379	Interdisciplinary Topics (with adviser consent)	
EE 263	Introduction to Linear Dynamical Systems	
EE 376A	Information Theory	
ENGR 205	Introduction to Control Design Techniques	
ENGR 209A	Analysis and Control of Nonlinear Systems	
MSE 251	Stochastic Control	
MSE 351	Dynamic Programming and Stochastic Control	
STATS 315A	Modern Applied Statistics: Learning	
STATS 315B	Modern Applied Statistics: Data Mining	
Track Electives (at least three additional courses from the above lists, the general CS electives list, or the following): [5]		9-13
CS 238	Decision Making under Uncertainty	
CS 275	Translational Bioinformatics	
CS 278		
CS 334A	Convex Optimization I	
or EE 364A	Convex Optimization I	
EE 364B	Convex Optimization II	
ECON 286	Game Theory and Economic Applications	
MSE 252	Decision Analysis I: Foundations of Decision Analysis	
MSE 352	Decision Analysis II: Professional Decision Analysis	
MSE 355	Influence Diagrams and Probabilistics Networks	
PHIL 152	Computability and Logic	
PSYCH 202	Cognitive Neuroscience	
PSYCH 204A	Human Neuroimaging Methods	
PSYCH 204B	Computational Neuroimaging: Analysis Methods	
STATS 200	Introduction to Statistical Inference	
STATS 202	Data Mining and Analysis	
STATS 205	Introduction to Nonparametric Statistics	

Biocomputation Track—

		Units
The Mathematics, Science, and Engineering Fundamentals requirements are non-standard for this track. See Handbook for Undergraduate Engineering Programs for details.		
Select one of the following:		3-4
CS 121	(Not given this year)	
CS 221	Artificial Intelligence: Principles and Techniques	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 229	Machine Learning	
CS 231A	Computer Vision: From 3D Reconstruction to Recognition	
Select one of the following:		

CS 173	A Computational Tour of the Human Genome	
or CS 273A	A Computational Tour of the Human Genome	
CS 262	Computational Genomics	
CS 270	Modeling Biomedical Systems: Ontology, Terminology, Problem Solving	
CS 274	Representations and Algorithms for Computational Molecular Biology	
CS 275	Translational Bioinformatics	
CS 279	Computational Biology: Structure and Organization of Biomolecules and Cells	
One additional course from the lists above or the following:		3-4
CS 124	From Languages to Information	
CS 145	Introduction to Databases	
CS 147	Introduction to Human-Computer Interaction Design	
CS 148	Introduction to Computer Graphics and Imaging	
CS 248	Interactive Computer Graphics	
One course selected from either the Biomedical Computation (BMC) 'Informatics' electives list (go to http://bmc.stanford.edu and select Informatics from the elective options), BIOE 101, or from the general CS electives list [5]		3-4
One course from the BMC Informatics elective list (go to http://bmc.stanford.edu)		3-4
One course from either the BMC Informatics, Cellular/Molecular, or Organs/Organisms electives lists		3-5
One course from either the BMC Cellular/Molecular or Organs/Organisms electives lists		3-5

Computer Engineering Track—

		Units
EE 108 & EE 180	Digital System Design and Digital Systems Architecture	6-8
Select two of the following:		8
EE 101A	Circuits I	
EE 101B	Circuits II	
EE 102A	Signal Processing and Linear Systems I	
EE 102B	Signal Processing and Linear Systems II	
Satisfy the requirements of one of the following concentrations:		
1) Digital Systems Concentration		
CS 140	Operating Systems and Systems Programming	
or CS 143	Compilers	
EE 109	Digital Systems Design Lab	
EE 271	Introduction to VLSI Systems	
Plus two of the following (6-8 units):		
CS 140	Operating Systems and Systems Programming (if not counted above)	
or CS 143	Compilers	
CS 144	Introduction to Computer Networking	
CS 149	Parallel Computing	
CS 240E		
CS 244	Advanced Topics in Networking	
EE 273	Digital Systems Engineering	
EE 282	Computer Systems Architecture	
2) Robotics and Mechatronics Concentration		
CS 205A	Mathematical Methods for Robotics, Vision, and Graphics	
CS 223A	Introduction to Robotics	
ME 210	Introduction to Mechatronics	
ENGR 105	Feedback Control Design	
Plus one of the following (3-4 units):		
CS 225A	Experimental Robotics	
CS 225B	Robot Programming Laboratory	
CS 231A	Computer Vision: From 3D Reconstruction to Recognition	
CS 277	Experimental Haptics	
ENGR 205	Introduction to Control Design Techniques	
ENGR 207A	Linear Control Systems I	
ENGR 207B	Linear Control Systems II	
3) Networking Concentration		
CS 140 & CS 144	Operating Systems and Systems Programming and Introduction to Computer Networking	
Plus three of the following (9-11 units):		
CS 240	Advanced Topics in Operating Systems	
CS 240E		
CS 241	Embedded Systems Workshop	
CS 244	Advanced Topics in Networking	
CS 244B	Distributed Systems	
CS 244E		
CS 249A	Object-Oriented Programming from a Modeling and Simulation Perspective	
CS 249B	Large-scale Software Development	
EE 179	Analog and Digital Communication Systems	

Graphics Track—

		Units
CS 148 & CS 248	Introduction to Computer Graphics and Imaging and Interactive Computer Graphics	8
Select one of the following: [6]		3-5
CS 205A	Mathematical Methods for Robotics, Vision, and Graphics (strongly recommended as a preferred choice)	
CME 104	Linear Algebra and Partial Differential Equations for Engineers (Note: students taking CME 104 are also required to take its prerequisite course, CME 102)	
CME 108	Introduction to Scientific Computing	
MATH 52	Integral Calculus of Several Variables	
MATH 113	Linear Algebra and Matrix Theory	
Select two of the following:		6-8
CS 178		
CS 231A	Computer Vision: From 3D Reconstruction to Recognition	
or CS 131	Computer Vision: Foundations and Applications	
CS 233	The Shape of Data: Geometric and Topological Data Analysis	
CS 268		
CS 348A	Computer Graphics: Geometric Modeling	
CS 348B	Computer Graphics: Image Synthesis Techniques	
CS 348V		
CS 448	Topics in Computer Graphics	
Track Electives: at least two additional courses from the lists above, the general CS electives list, or the following: [5]		6-8
ARTSTUDI 160	Intro to Digital / Physical Design	

ARTSTUDI 170	Introduction to Photography
ARTSTUDI 179	Digital Art I
CME 302	Numerical Linear Algebra
CME 306	Numerical Solution of Partial Differential Equations
EE 262	Two-Dimensional Imaging
EE 264	Digital Signal Processing
EE 278	Introduction to Statistical Signal Processing
EE 368	Digital Image Processing
ME 101	Visual Thinking
PSYCH 30	Introduction to Perception
PSYCH 221	Applied Vision and Image Systems

Human-Computer Interaction Track—

		Units
CS 147	Introduction to Human-Computer Interaction Design	4
CS 247	Human-Computer Interaction Design Studio	4
Any three of the following:		4
CS 142	Web Applications	
CS 148	Introduction to Computer Graphics and Imaging	
CS 194H	User Interface Design Project	
CS 210A	Software Project Experience with Corporate Partners	
CS 376	Human-Computer Interaction Research	
Any CS 377A/B/C/ 'Topics in HCI' of three or more units		
CS 448B	Data Visualization	
ME 216M		
At least two additional courses from above list, the general CS electives list, or the following: [5]		3-6
Any d.school class of 3+ units; any class of 3+ units at hci.stanford.edu under the 'courses' link:		
Communication-		
COMM 121	Behavior and Social Media	
COMM 124	Digital Deception	
or COMM 224	Digital Deception	
COMM 140	Digital Media Entrepreneurship	
or COMM 240	Digital Media Entrepreneurship	
COMM 166	Virtual People	
COMM 169	Computers and Interfaces	
or COMM 269	Computers and Interfaces	
COMM 172	Media Psychology	
or COMM 272	Media Psychology	
COMM 182		
COMM 324	Language and Technology	
Art Studio-		
ARTSTUDI 160	Intro to Digital / Physical Design	
ARTSTUDI 162	Embodied Interfaces	
ARTSTUDI 163	Drawing with Code	
ARTSTUDI 164	DESIGN IN PUBLIC SPACES	
ARTSTUDI 165	Social Media and Performative Practices	
ARTSTUDI 168	Data as Material	
ARTSTUDI 264	Advanced Interaction Design	
ARTSTUDI 266	Sulptural Screens / Malleable Media	
ARTSTUDI 267	Emerging Technology Studio	
Sym Sys-		
SYMSYS 245	Cognition in Interaction Design	
Psychology-		
PSYCH 30	Introduction to Perception	
PSYCH 45	Introduction to Learning and Memory	
PSYCH 70	Introduction to Social Psychology	
PSYCH 75	Introduction to Cultural Psychology	
PSYCH 110	Research Methods and Experimental Design	
PSYCH 131	Language and Thought	
PSYCH 154	Judgment and Decision-Making	
Empirical Methods-		
MSE 125	Introduction to Applied Statistics	
PSYCH 252	Statistical Methods for Behavioral and Social Sciences	
PSYCH 254	Lab in Experimental Methods	
PSYCH 110	Research Methods and Experimental Design	
STATS 203	Introduction to Regression Models and Analysis of Variance	
EDUC 191X		
HUMBIO 82A	Qualitative Research Methodology	
ME Design-		
ME 101	Visual Thinking	
ME 115A	Introduction to Human Values in Design	
ME 203	Design and Manufacturing	
ME 210	Introduction to Mechatronics	
ME 216A	Advanced Product Design: Needfinding	
Learning Design + Tech-		
EDUC 281X		
EDUC 239X		
EDUC 338X		
EDUC 342	Child Development and New Technologies	
MS&E-		
MSE 185	Global Work	
MSE 331		
Computer Music-		
MUSIC 220A	Fundamentals of Computer-Generated Sound	
MUSIC 220B	Compositional Algorithms, Psychoacoustics, and Computational Music	
MUSIC 220C	Research Seminar in Computer-Generated Music	
MUSIC 250A	Physical Interaction Design for Music	
Optional Elective [5]		

Information Track—

		Units
CS 124	From Languages to Information	4
CS 145	Introduction to Databases	4
Two courses, from different areas:		6-9

1) Information-based AI applications	
CS 224N	Natural Language Processing
CS 224S	Spoken Language Processing
CS 229	Machine Learning
CS 229A	(Not given this year)
CS 233	The Shape of Data: Geometric and Topological Data Analysis
2) Database and Information Systems	
CS 140	Operating Systems and Systems Programming
CS 142	Web Applications
CS 245	Database Systems Principles
CS 246	Mining Massive Data Sets
CS 341	Project in Mining Massive Data Sets
CS 345	(Offered occasionally)
CS 346	Database System Implementation
CS 347	Parallel and Distributed Data Management
3) Information Systems in Biology	
CS 262	Computational Genomics
CS 270	Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
CS 274	Representations and Algorithms for Computational Molecular Biology
4) Information Systems on the Web	
CS 224W	Social Information and Network Analysis
CS 276	Information Retrieval and Web Search
CS 364B	(Not given this year)
At least three additional courses from the above areas or the general CS electives list. [5]	

Systems Track—

		Units
CS 140	Operating Systems and Systems Programming	4
Select one of the following:		3-4
CS 143	Compilers	
EE 180	Digital Systems Architecture	
Two additional courses from the list above or the following:		6-8
CS 144	Introduction to Computer Networking	
CS 145	Introduction to Databases	
CS 149	Parallel Computing	
CS 155	Computer and Network Security	
CS 240	Advanced Topics in Operating Systems	
CS 242	Programming Languages	
CS 243	Program Analysis and Optimizations	
CS 244	Advanced Topics in Networking	
CS 245	Database Systems Principles	
EE 271	Introduction to VLSI Systems	
EE 282	Computer Systems Architecture	
Track Electives: at least three additional courses selected from the list above, the general CS electives list, or the following: [5]		9-12
CS 240E		
CS 241	Embedded Systems Workshop	
CS 244C	Readings and Projects in Distributed Systems	
CS 244E		
CS 315A	Parallel Computer Architecture and Programming	
or CS 316	Advanced Multi-Core Systems	
CS 341	Project in Mining Massive Data Sets	
CS 343	(Not given this year)	
CS 344	Topics in Computer Networks	
CS 345	(Offered occasionally)	
CS 346	Database System Implementation	
CS 347	Parallel and Distributed Data Management	
CS 349	Topics in Programming Systems (with permission of undergraduate advisor)	
CS 448	Topics in Computer Graphics	
EE 382C	Interconnection Networks	
EE 384A	Internet Routing Protocols and Standards	
EE 384B	Multimedia Communication over the Internet	
EE 384C	Wireless Local and Wide Area Networks	
EE 384S	Performance Engineering of Computer Systems & Networks	
EE 384X	Packet Switch Architectures	

Theory Track—

		Units
CS 154	Introduction to Automata and Complexity Theory	4
Select one of the following:		3
CS 167	Readings in Algorithms (Not given this year)	
CS 168	The Modern Algorithmic Toolbox	
CS 255	Introduction to Cryptography	
CS 261	Optimization and Algorithmic Paradigms	
CS 264		
CS 265	Randomized Algorithms and Probabilistic Analysis	
CS 268		
CS 361A		
CS 361B		
Two additional courses from the list above or the following:		6-8
CS 143	Compilers	
CS 155	Computer and Network Security	
CS 157	Logic and Automated Reasoning	
or PHIL 151	Metalogic	
CS 166	Data Structures	
CS 205A	Mathematical Methods for Robotics, Vision, and Graphics	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 233	The Shape of Data: Geometric and Topological Data Analysis	
CS 242	Programming Languages	
CS 254		
CS 259	((With adviser consent); Not given this year)	
CS 262	Computational Genomics	
CS 263	Algorithms for Modern Data Models	
CS 266		
CS 267	Graph Algorithms	
CS 354	Topics in Circuit Complexity (Not given this year)	
CS 355	(Not given this year)	
CS 357	Advanced Topics in Formal Methods (Not given this year)	
CS 358	Topics in Programming Language Theory	
CS 359	Topics in the Theory of Computation (with adviser consent)	
CS 364A	Algorithmic Game Theory	
CS 364B	(Not given this year)	

CS 366	(Not given this year)	
CS 367	Algebraic Graph Algorithms (Not given this year)	
CS 369	Topics in Analysis of Algorithms (with adviser consent)	
CS 374	Algorithms in Biology	
MSE 310	Linear Programming	
Track Electives: at least three additional courses from the list above, the general CS electives list, or the following: [5]		9-12
CME 302	Numerical Linear Algebra	
CME 305	Discrete Mathematics and Algorithms	
PHIL 152	Computability and Logic	

Unspecialized Track—

		Units
CS 154	Introduction to Automata and Complexity Theory	4
Select one of the following:		4
CS 140	Operating Systems and Systems Programming	
CS 143	Compilers	
One additional course from the list above or the following:		3-4
CS 144	Introduction to Computer Networking	
CS 155	Computer and Network Security	
CS 242	Programming Languages	
CS 244	Advanced Topics in Networking	
EE 180	Digital Systems Architecture	
Select one of the following:		3-4
CS 121	(Not given this year)	
CS 221	Artificial Intelligence: Principles and Techniques	
CS 223A	Introduction to Robotics	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 229	Machine Learning	
CS 231A	Computer Vision: From 3D Reconstruction to Recognition	
Select one of the following:		3-4
CS 145	Introduction to Databases	
CS 147	Introduction to Human-Computer Interaction Design	
CS 148	Introduction to Computer Graphics and Imaging	
CS 248	Interactive Computer Graphics	
CS 262	Computational Genomics	
At least two courses from the general CS electives list [5]		

Individually Designed Track —

Students may propose an individually designed track. Proposals should include a minimum of seven courses, at least four of which must be CS courses numbered 100 or above. See Handbook for Undergraduate Engineering Programs for further information.

Senior Capstone Project (3 units minimum)

CS 191	Senior Project [7]
CS 191W	Writing Intensive Senior Project [7]
CS 194	Software Project
CS 194H	User Interface Design Project
CS 194W	Software Project
CS 210B	Software Project Experience with Corporate Partners
CS 294W	Writing Intensive Research Project in Computer Science

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

1. MATH 19, MATH 20, and MATH 21 may be taken instead of MATH 41 and MATH 42 as long as at least 26 MATH units are taken. AP Calculus must be approved by the School of Engineering.
2. The math electives list consists of: MATH 51, MATH 104, MATH 108, MATH 109, MATH 110, MATH 113; CS 157, CS 205A; PHIL 151; CME 100, CME 102, CME 104. Completion of MATH 52 and MATH 53 counts as one math elective. Restrictions: CS 157 and PHIL 151 may not be used in combination to satisfy the math electives requirement. Students who have taken both MATH 51 and MATH 52 may not count CME 100 as an elective. Courses counted as math electives cannot also count as CS electives, and vice versa.
3. The science elective may be any course of 3 or more units from the School of Engineering Science list plus PSYCH 30; AP Chemistry may be used to meet this requirement. Either of the PHYSICS sequences 61/63 or 21/23 may be substituted for 41/43 as long as at least 11 science units are taken. AP Physics must be approved by the School of Engineering.
4. Students who take ENGR 40A (3 units) are required to take two additional units of ENGR Fundamentals (13 units minimum), or 2 additional units of Depth (27 units minimum for track and elective courses).
5. General CS Electives: CS 108,CS 124, CS 131, CS 140, CS 142, CS 143 CS 144, CS 145, CS 147, CS 148, CS 149, CS 154, CS 155, CS 157(or PHIL 151), CS 164, CS 166, CS 167, CS 168, CS 190, CS 205A, CS 205B, CS 210A, CS 223A, CS 224M, CS 224N, CS 224S, CS 224U, CS 224W, CS 225A, CS 225B, CS 227B, CS 228, CS 228T, CS 229, CS 229A, CS 229T, CS 231A, CS 231B, CS 231M, CS 231N, CS 232, CS 233, CS 240, CS 240H, CS 242, CS 243, CS 244, CS 244B, CS 245, CS 246, CS 247, CS 248, CS 249A, CS 249B, CS 251, CS 254, CS 255, CS 261, CS 262, CS 263, CS 264, CS 265, CS 266, CS 267, CS 270, CS 272, CS 173 or CS 273A, CS 274, CS 276, CS 277, CS 279, CS 348B; CME 108; EE 180, EE 282, EE 364A.
6. CS 205A Mathematical Methods for Robotics, Vision, and Graphics is recommended in this list for the Graphics track. Students taking CME 104 Linear Algebra and Partial Differential Equations for Engineers are also required to take its prerequisite, CME 102 Ordinary Differential Equations for Engineers.
7. Independent study projects (CS 191 Senior Projector CS 191W Writing Intensive Senior Project) require faculty sponsorship and must be approved by the adviser, faculty sponsor, and the CS senior project adviser (P. Young). A signed approval form, along with a brief description of the proposed project, should be filed the quarter before work on the project is begun. Further details can be found in the *Handbook for Undergraduate Engineering Programs*.

Electrical Engineering (EE)

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

Mission of the Undergraduate Program in Electrical Engineering

The mission of the undergraduate program of the Department of Electrical Engineering is to augment the liberal education expected of all Stanford undergraduates, to impart basic understanding of electrical engineering and to develop skills in the design and building of systems that directly impact societal needs. The program includes a balanced foundation in the physical sciences, mathematics and computing; core courses in electronics, information systems and digital systems; and develops specific skills in the analysis and design of systems. Students in the major have broad flexibility to select from many specialization areas beyond the core, including areas in electronics, optics, information systems and hardware and software systems as well as application-oriented cross-cuts in bio-instrumentation and bio-imaging, energy and environment and music. The program prepares students for a broad range of careers—both industrial and government—as well as for professional and academic graduate education.

Requirements

Mathematics		
MATH 41	Calculus	5
MATH 42	Calculus	5
Select one 2-course sequence:		10
CME 100 & CME 102	Vector Calculus for Engineers and Ordinary Differential Equations for Engineers (Same as ENGR 154)	
MATH 52 & MATH 53	Integral Calculus of Several Variables and Ordinary Differential Equations with Linear Algebra	
EE Math. One additional 100-level course. Select one of the following:		3
EE 102B	Signal Processing and Linear Systems II (if not used in Depth)	
EE 103	Introduction to Matrix Methods	
EE 142	Engineering Electromagnetics	
CME 104/ ENGR 155B	Linear Algebra and Partial Differential Equations for Engineers	
MATH 113	Linear Algebra and Matrix Theory	
CS 103	Mathematical Foundations of Computing	
Statistics/Probability. Select one of the following: [1]		3-4
EE 178	Probabilistic Systems Analysis (Preferred)	
CS 109	Introduction to Probability for Computer Scientists	
Science		
Select one of the following sequences:		8
PHYSICS 41 & PHYSICS 43	Mechanics and Electricity and Magnetism [2]	
PHYSICS 61 & PHYSICS 63	Mechanics and Special Relativity and Electricity, Magnetism, and Waves	
Science elective. One additional 4-5 unit course from approved list in Undergraduate Handbook, Figure 3-2. [3]		4-5
Technology in Society		
One course, see Basic Requirement 4 in the School of Engineering section		3-5
Engineering Fundamentals [4]		
Select one of the following:		
CS 106B/ENGR 70B	Programming Abstractions	5
or CS 106X/ ENGR 70X	Programming Abstractions (Accelerated)	
At least two additional courses, at least one of which is not in EE or CS (CS 106A is not allowed). Choose from table in Undergraduate Handbook, Figure 3-4. One from ENGR 40 or ENGR 40M recommended.		8-10
Writing in the Major (WIM)		
Select one of the following:		3-4
EE 109	Digital Systems Design Lab (WIM/Design)	
EE 133	Analog Communications Design Laboratory (WIM/ Design)	
EE 134	Introduction to Photonics (WIM/Design)	
EE 153	Power Electronics (WIM/Design)	
EE 155	Green Electronics (WIM/Design)	
EE 168	Introduction to Digital Image Processing (WIM/ Design)	
EE 191W	Special Studies and Reports in Electrical Engineering (WIM; Department approval required) [5]	
CS 194W	Software Project (WIM/Design)	
Core Electrical Engineering Courses		
EE 100	The Electrical Engineering Profession [6]	1
EE 101A	Circuits I	4
EE 102A	Signal Processing and Linear Systems I	4
EE 108	Digital System Design	4
Physics in Electrical Engineering. Students must complete one of the following courses:		3-5
EE 65	Modern Physics for Engineers (Preferred)	
EE 142	Engineering Electromagnetics [7]	
Depth Courses		14
Select four courses from one of the following Depth areas. Courses must include one required course, one Design course, and 2 additional courses.		
Design Course		3-4
Select one of the following:		
EE 109	Digital Systems Design Lab (WIM/Design)	
EE 133	Analog Communications Design Laboratory (WIM/ Design)	
EE 134	Introduction to Photonics (WIM/Design)	
EE 153	Power Electronics (WIM/Design)	
EE 155	Green Electronics (WIM/Design)	
EE 168	Introduction to Digital Image Processing (WIM/ Design)	
EE 262	Two-Dimensional Imaging (Design)	
EE 264	Digital Signal Processing [8]	
CS 194W	Software Project (WIM/Design)	
Additional Electives		12
May include up to two additional Engineering Fundamentals, any CS 193 course and any letter graded EE or EE Related courses (minus any previously noted restrictions). Freshman and Sophmore seminars, EE191 and CS 106A do not count toward the 60 units.		

1. CME 106 or STATS 116 can also fulfill the Statistics/Probability requirement, but these are not preferred.
2. The EE introductory class ENGR 40 or ENGR 40M may be taken concurrently with PHYSICS 43. PHYSICS 43 is not a prerequisite for ENGR 40 or 40M. Many students find the material complementary in terms of fundamental and applied perspectives on electronics.
3. A minimum of 12 science units must be taken. A minimum of 40 math and science units combined must be taken.
4. EE Engineering Topics: Fundamentals and Depth courses must total 60 units minimum.
5. EE 191W may satisfy WIM only if it is a follow-up to an REU, independent study project or as part of an honors thesis project where a faculty agrees to provide supervision of writing a technical paper and with suitable support from the Writing Center.
6. For upper division students, a 200-level seminar in their depth area will be accepted, on petition.
7. EE 142 cannot be double counted. It may be used for only one of: Math; Physics in Electrical Engineering; or as a depth elective.

8 To satisfy Design, EE 264 must be taken for 4 units and complete the laboratory project.

Depth Areas

		Units
Bio-electronics and Bio-imaging		
EE 101B	Circuits II (Required)	4
or EE 102B	Signal Processing and Linear Systems II	
EE 122B	Introduction to Biomedical Electronics	3
EE 124	Introduction to Neuroelectrical Engineering	3
EE 134	Introduction to Photonics (WIM/Design)	4
EE 168	Introduction to Digital Image Processing (WIM/ Design)	4
EE 169	Introduction to Bioimaging	3
EE 202	Electrical Engineering in Biology and Medicine	3
EE 225	Biochips and Medical Imaging	3
MED 275B	Biomedical Innovation Incubator	2-5
Circuits and Devices		
EE 101B	Circuits II (Required)	4
EE 114	Fundamentals of Analog Integrated Circuit Design	3
EE 116	Semiconductor Device Physics	3
EE 118	Introduction to Mechatronics	4
EE 122A	Analog Circuits Laboratory	3
EE 133	Analog Communications Design Laboratory (WIM/ Design)	4
EE 153	Power Electronics (WIM/Design)	3-4
EE 155	Green Electronics (WIM/Design)	4
EE 212	Integrated Circuit Fabrication Processes	3
EE 213	Digital MOS Integrated Circuits	3
EE 214B	Advanced Analog Integrated Circuit Design	3
EE 216	Principles and Models of Semiconductor Devices	3
EE 271	Introduction to VLSI Systems	3
Computer Hardware		
CS 107	Computer Organization and Systems (Prerequisite for EE 180)	3-5
or CS 107E	Computer Systems from the Ground Up	
EE 107	Networked Systems	3
EE 180	Digital Systems Architecture (Required)	4
EE 109	Digital Systems Design Lab (WIM/Design)	4
EE 118	Introduction to Mechatronics	4
EE 155	Green Electronics (WIM/Design)	4
EE 213	Digital MOS Integrated Circuits	3
EE 271	Introduction to VLSI Systems	3
EE 273	Digital Systems Engineering	3
EE 282	Computer Systems Architecture	3
CS 110	Principles of Computer Systems	3-5
CS 140	Operating Systems and Systems Programming	3-4
CS 143	Compilers	3-4
CS 144	Introduction to Computer Networking	3-4
CS 148	Introduction to Computer Graphics and Imaging	3-4
Computer Software		
CS 107	Computer Organization and Systems (Prerequisite for EE 180)	3-5
or CS 107E	Computer Systems from the Ground Up	
EE 107	Networked Systems	3
EE 180	Digital Systems Architecture (Required)	4
CS 108	Object-Oriented Systems Design	3-4
CS 110	Principles of Computer Systems	3-5
CS 140	Operating Systems and Systems Programming	3-4
CS 143	Compilers	3-4
CS 144	Introduction to Computer Networking	3-4
CS 145	Introduction to Databases	3-4
CS 148	Introduction to Computer Graphics and Imaging	3-4
CS 155	Computer and Network Security	3
EE 155	Green Electronics (WIM/Design)	4
CS 194W	Software Project (WIM/Design)	3
Energy and Environment		
EE 101B	Circuits II (Required)	4
or EE 180	Digital Systems Architecture	
EE 116	Semiconductor Device Physics	3
EE 134	Introduction to Photonics (WIM/Design)	4
EE 151	Sustainable Energy Systems	3
EE 155	Green Electronics (WIM/Design)	4
EE 153	Power Electronics (WIM/Design)	3-4
EE 168	Introduction to Digital Image Processing (WIM/ Design)	3-4
EE 263	Introduction to Linear Dynamical Systems	3
EE 293A	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	3-4
EE 293B	Fundamentals of Energy Processes	3
CEE 155	Introduction to Sensing Networks for CEE	4
CEE 107A	Understanding Energy (Formerly CEE 173A)	3
CEE 176A	Energy Efficient Buildings	3-4
CEE 176B	Electric Power: Renewables and Efficiency	3-4
ENGR 105	Feedback Control Design	3
ENGR 205	Introduction to Control Design Techniques	3
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	3-4
ME 185	Electric Vehicle Design	3
Music		
EE 102B	Signal Processing and Linear Systems II (Required)	4
or MUSIC 320B	Introduction to Audio Signal Processing Part II: Digital Filters	
EE 109	Digital Systems Design Lab (WIM/Design)	4
EE 122A	Analog Circuits Laboratory	3
EE 264	Digital Signal Processing	4
MUSIC 256A	Music, Computing, Design I: Art of Design for Computer Music	1-4
MUSIC 256B	Music, Computing, Design II: Virtual and Augmented Reality for Music	3-4
MUSIC 320A	Introduction to Audio Signal Processing Part I: Spectrum Analysis	3-4
MUSIC 420A	Signal Processing Models in Musical Acoustics	3-4
MUSIC 421A	Audio Applications of the Fast Fourier Transform	3-4
MUSIC 422	Perceptual Audio Coding	3
MUSIC 424	Signal Processing Techniques for Digital Audio Effects	3-4
Photonics, Solid State and Electromagnetics		
EE 101B	Circuits II (Required)	4
EE 116	Semiconductor Device Physics	3
EE 134	Introduction to Photonics (WIM/Design)	4
EE 136	Introduction to Nanophotonics and Nanostructures	3
EE 142	Engineering Electromagnetics	3
EE 216	Principles and Models of Semiconductor Devices	3

EE 222	Applied Quantum Mechanics I	3
EE 223	Applied Quantum Mechanics II	3
EE 228	Basic Physics for Solid State Electronics	3
EE 236A	Modern Optics	3
EE 236B	Guided Waves	3
EE 242	Electromagnetic Waves	3
EE 247	Introduction to Optical Fiber Communications	3
Signal Processing, Communications and Controls		
EE 102B	Signal Processing and Linear Systems II (Required)	4
EE 107	Networked Systems	3
EE 124	Introduction to Neuroelectrical Engineering	3
EE 169	Introduction to Bioimaging	3
EE 261	The Fourier Transform and Its Applications	3
EE 263	Introduction to Linear Dynamical Systems	3
EE 264	Digital Signal Processing	4
EE 278	Introduction to Statistical Signal Processing	3
EE 279	Introduction to Digital Communication	3
ENGR 105	Feedback Control Design	3
ENGR 205	Introduction to Control Design Techniques	3

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

Engineering Physics (EPHYS)

Completion of the undergraduate program in Engineering Physics leads to the conferral of the Bachelor of Science in Engineering. The subplan "Engineering Physics" appears on the transcript and on the diploma.

Mission of the Undergraduate Program in Engineering Physics

The mission of the undergraduate program in Engineering Physics is to provide students with a strong foundation in physics and mathematics, together with engineering and problem-solving skills. All majors take high-level math and physics courses as well as engineering courses. This background prepares them to tackle complex problems in multidisciplinary areas that are at the forefront of 21st-century technology such as aerospace physics, biophysics, computational science, solid state devisces, quantum optics and photonics, materials science, nanotechnology, electromechanical systems, energy systems, renewable energy, and any other engineering field that requires a solid background in physics. Because the program emphasizes science, mathematics, and engineering, students are well prepared to pursue graduate work in engineering, physics, or applied physics.

Requirements

		Units
Mathematics		
Select one of the following sequences:		10
MATH 51 & MATH 52	Linear Algebra and Differential Calculus of Several Variables and Integral Calculus of Several Variables	
CME 100 & CME 104	Vector Calculus for Engineers and Linear Algebra and Partial Differential Equations for Engineers	
MATH 53	Ordinary Differential Equations with Linear Algebra	5
or CME 102	Ordinary Differential Equations for Engineers	
MATH 131P	Partial Differential Equations I (or CME 204 or MATH 173)	3
Science		
PHYSICS 41	Mechanics (or PHYSICS 61)	4
PHYSICS 42	Classical Mechanics Laboratory (or PHYSICS 62) [1]	1
PHYSICS 43	Electricity and Magnetism (or PHYSICS 63)	4
PHYSICS 67	Introduction to Laboratory Physics [2]	2
PHYSICS 45	Light and Heat (or PHYSICS 65)	4
PHYSICS 46	Light and Heat Laboratory (or PHYSICS 67)	1
PHYSICS 70	Foundations of Modern Physics (if taking the 40 series)	4
Technology in Society		
One course required, see Basic Requirement 4		3-5
Engineering Fundamentals		
Three courses minimum (CS 106A or X recommended) [3]		9-14
Engineering Physics Depth (core)		
Advanced Mathematics:		
One advanced math elective such as		3-5
EE 261	The Fourier Transform and Its Applications	
PHYSICS 112	Mathematical Methods of Physics	
CS 109	Introduction to Probability for Computer Scientists	
CME 106	Introduction to Probability and Statistics for Engineers	
Also qualified are EE 263, any Math or Statistics course numbered 100 or above, and any CME course numbered 200 or above, except CME 206.		
Advanced Mechanics: [4]		3-4
AA 242A	Classical Dynamics (or ME 333 or PHYSICS 110)	3
Intermediate Electricity and Magnetism		6-8
Select one of the following sequences:		
PHYSICS 120 & PHYSICS 121	Intermediate Electricity and Magnetism I and Intermediate Electricity and Magnetism II	
EE 142 & EE 242	Engineering Electromagnetics and Electromagnetic Waves	
Numerical Methods		
Select one of the following:		3-4
APPPHYS 215	Numerical Methods for Physicists and Engineers	
CME 108	Introduction to Scientific Computing	
CME 206/ME 300C	Introduction to Numerical Methods for Engineering	
PHYSICS 113	Computational Physics	
Electronics Lab		
Select one of the following:		3-5
ENGR 40	Introductory Electronics (ENGR 40A is not allowed)	
EE 101B	Circuits II	
EE 122A	Analog Circuits Laboratory	
PHYSICS 105	Intermediate Physics Laboratory I: Analog Electronics	
APPPHYS 207	Laboratory Electronics	
Writing Lab (WIM)		
Select one of the following:		4-5
AA 190	Directed Research and Writing in Aero/Astro (for Aerospace specialty only)	
ENGR 199W	Writing of Original Research for Engineers (for students pursuing an independent research project)	
BIOE 131	Ethics in Bioengineering (for Biophysics specialty only)	
CS 181W	Computers, Ethics, and Public Policy (for Computational Science specialty only)	

EE 134	Introduction to Photonics (for Photonics specialty only)	
EE 155	Green Electronics (for Renewable Energy specialty only)	
ME 112	Mechanical Systems Design (for Electromechanical System Design specialty only)	
ME 131A & ME 140	Heat Transfer and Advanced Thermal Systems (for Energy Systems specialty only)	
MATSCI 161	Nanocharacterization Laboratory (Okay for Materials Science and Renewable Energy specialties)	
MATSCI 164	Electronic and Photonic Materials and Devices Laboratory (Okay for Materials Science and Renewable Energy specialties)	
PHYSICS 107	Intermediate Physics Laboratory II: Experimental Techniques and Data Analysis (for Phontonics specialty)	
Quantum Mechanics		
Select one of the following sequences:		6-8
EE 222 & EE 223	Applied Quantum Mechanics I and Applied Quantum Mechanics II	
PHYSICS 130 & PHYSICS 131	Quantum Mechanics I and Quantum Mechanics II	
Thermodynamics and Statistical Mechanics		
PHYSICS 170 & PHYSICS 171	Thermodynamics, Kinetic Theory, and Statistical Mechanics I and Thermodynamics, Kinetic Theory, and Statistical Mechanics II	3-8
or ME 346A	Introduction to Statistical Mechanics	
Design Course		
Select one of the following:		3-4
AA 236A	Spacecraft Design	
CS 108	Object-Oriented Systems Design	
EE 133	Analog Communications Design Laboratory	
ME 203	Design and Manufacturing	
ME 210	Introduction to Mechatronics	
PHYSICS 108	Advanced Physics Laboratory: Project	
Specialty Tracks		
Select three courses from one specialty area:		9-12
Aerospace Physics:		
AA 203	Introduction to Optimal Control Theory	
AA 244A	Introduction to Plasma Physics and Engineering	
AA 251	Introduction to the Space Environment	
AA 279A	Space Mechanics	
ME 161	Dynamic Systems, Vibrations and Control	
Materials Science:		
Any MATSCI courses numbered 151 to 199 (except 159Q) or PHYSICS 172		
Electromechanical System Design:		
ME 80	Mechanics of Materials	
ME 112	Mechanical Systems Design	
ME 210	Introduction to Mechatronics	
or EE 118	Introduction to Mechatronics	
Energy Systems:		
ME 131A	Heat Transfer	
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	
ME 140	Advanced Thermal Systems	
Renewable Energy:		
CEE 176B	Electric Power: Renewables and Efficiency	
EE 153	Power Electronics	
EE 155	Green Electronics	
EE 237	Solar Energy Conversion	
EE 293A	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
EE 293B	Fundamentals of Energy Processes	
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
MATSCI 302	Solar Cells	
MATSCI 316	Nanoscale Science, Engineering, and Technology	
ME 260	Fuel Cell Science and Technology	
Biophysics:		
APPPHYS 205	Introduction to Biophysics	
BIO 132	Advanced Imaging Lab in Biophysics	
BIOE 41	Physical Biology of Macromolecules	
BIOE 42	Physical Biology of Cells	
BIOE 44	Fundamentals for Engineering Biology Lab	
BIOE 101	Systems Biology	
BIOE 103	Systems Physiology and Design	
BIOE 123	Optics and Devices Lab	
CS 262	Computational Genomics	
EE 169	Introduction to Bioimaging	
or EE 369A	Medical Imaging Systems I	
Computational Science:		
CME 212	Advanced Programming for Scientists and Engineers	
CME 215A	Advanced Computational Fluid Dynamics	
CME 215B	Advanced Computational Fluid Dynamics	
Any CME course with course number greater than 300 and less than 390		
CS 103	Mathematical Foundations of Computing	
CS 154	Introduction to Automata and Complexity Theory	
CS 161	Design and Analysis of Algorithms	
CS 205A	Mathematical Methods for Robotics, Vision, and Graphics	
CS 205B	Mathematical Methods for Fluids, Solids, and Interfaces	
CS 221	Artificial Intelligence: Principles and Techniques	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 229	Machine Learning	3-4
STATS 202	Data Mining and Analysis	
STATS 213	Introduction to Graphical Models	
Total Units		**99-127**

1 PHYSICS 42 Classical Mechanics Laboratory or PHYSICS 62 Mechanics Laboratory, Mechanics Lab (1 unit), required in 2011-12 and beyond

2 PHYSICS 67 Introduction to Laboratory Physics (2 units), recommended in place of PHYSICS 44 Electricity and Magnetism Lab

3 The Engineering Fundamental courses are to be selected from the Basic Requirements 3 list. Fundamentals courses acceptable for the core program may also be used to satisfy the fundamentals requirement as long as 45 unduplicated units of Engineering are taken.

4 ENGR 15 Dynamics, allowed for students who matriculated in 2011/2012 or earlier; however, AA 242A Classical Dynamics, ME 333 Mechanics or PHYSICS 110 Advanced Mechanics recommended instead of, or in addition to, ENGR 15 Dynamics.

5 Although not required, PHYSICS 59 (https://explorecourses.stanford.edu/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&academicYear=&q=physics59&collapse=) (Frontiers in Physics Research, 1 unit) and PHYSICS 91SI (https://explorecourses.stanford.edu/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&academicYear=&q=physics91si&collapse=) (Practical Computing for Scientists, 2 units) are highly recommended.

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

Honors Program

The School of Engineering offers a program leading to a Bachelor of Science in Engineering: Engineering Physics with Honors.

Honors Criteria

1. Minimum overall GPA of 3.5.
2. Independent research conducted at an advanced level with a faculty research adviser and documented in an honors thesis. The honors candidate must identify a faculty member who will serve as his or her honors research adviser and a second reader who will be asked to read the thesis and give feedback before endorsing the thesis. One of the two must be a member of the Academic Council and in the School of Engineering.

Application: The deadline to apply is October 15 in Autumn Quarter of the senior year. The application documents should be submitted to the student services officer. Applications are reviewed by a subcommittee of the faculty advisers for Engineering Physics majors. Applicants and thesis advisers receive written notification when the application is approved. An application consists of three items:

1. One-page description of the research topic
2. Application form (http://www.stanford.edu/group/ughb/2011-12/2012-13/EPhysHonorsReq_App_2012.doc) signed by the honors thesis adviser
3. Unofficial Stanford transcript

Requirements and Timeline for Honors in Engineering Physics:

1. Declare the honors program in Axess (ENGR-BSH, Subplan: Engineering Physics)
2. Obtain application form from the student services officer.
3. Apply to honors program by October 15 in the autumn quarter of the senior year.
4. Maintain an overall GPA of at least 3.5.
5. Optional: Under direction of the thesis adviser, students may enroll for research units in ENGR 199(W) or in departmental courses such as ME 191(H).
6. Submit a completed thesis draft to the research adviser and second reader by April 15.
7. Present the thesis work in an oral presentation or poster session in an appropriate forum (e.g., an event that showcases undergraduate research and is organized by the department of the adviser, the school of the adviser, or the university).
8. Incorporate feedback, which the adviser and second reader should provide by April 30, and obtain final endorsement signatures from the thesis adviser and second reader by May 15.
9. Submit two signed, single-sided copies to the student services officer by May 15.

Environmental Systems Engineering (EnvSE)

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

Environmental Engineering (ENV)

The program in Environmental Engineering has been discontinued. Students currently enrolled in this program should consult the previous year's Stanford Bulletin (http://exploredegrees.stanford.edu/archive/2012-13/schoolofengineering/civilandenvironmentalengineering/#bachelorofsciencetext-enviengi) for program requirements (click on Environmental Engineering in the right hand menu). Any current Environmental Engineering major wishing ABET accreditation must graduate by June 2015.

Mission of the Undergraduate Program in Environmental Systems Engineering

The mission of the undergraduate program in Environmental Systems Engineering is to prepare students for incorporating environmentally sustainable design, strategies and practices into natural and built systems and infrastructure involving buildings, water supply, and coastal regions. Courses in the program are multidisciplinary in nature, combining math/science/engineering fundamentals, and tools and skills considered essential for an engineer, along with a choice of one of three focus areas for more in-depth study: coastal environments, freshwater environments, or urban environments. This major offers the opportunity for a more focused curriculum than the Environmental and Water Studies concentration in the Civil Engineering degree program. The program of study, which includes a capstone experience, aims to equip engineering students to take on the complex challenges of the 21st Century involving natural and built environments, in consulting and industry as well as in graduate school.

Requirements

Mathematics and Science		
See Basic Requirement 1 and 2 [1]		36
Technology in Society (TiS)		
One 3-5 unit course required, see Basic Requirement 4		3-5
Engineering Fundamentals		
Three courses minimum (see Basic Requirement 3), including:		
ENGR 70A	Programming Methodology	5
(or ENGR 70X)		
(req'd) plus one of the following courses:		
ENGR 90 Environmental Science and Technology		
(req'd for Freshwater and Coastal focus areas)		
or		
CEE 146A	Engineering Economy	3
(req'd for Urban focus area)		
plus one Engineering Fundamentals Elective		3-5
Fundamental Tools/Skills [2]		9
in Visual, Oral/Written Communication, and Modeling/Analysis		
Specialty Courses, in either		37

Coastal Environments (see Below)		
or Freshwater Environments (see Below)		
or Urban Environments (see Below)		
Total Units		96-100

[1] Math must include CME 100 Vector Calculus for Engineers (or MATH 51 Linear Algebra and Differential Calculus of Several Variables), and either a Probability/Statistics course or CME 102 Ordinary Differential Equations for Engineers (or MATH 53 Ordinary Differential Equations with Linear Algebra). Science must include PHYSICS 41 Mechanics; and either Engr 31 Chemical Principles with Application to Nanoscale Science and Technology, CHEM 31B Chemical Principles II or CHEM 31X Chemical Principles Accelerated (or PHYSICS 43 Electricity and Magnetism, for Urban focus area only).

[2] Fundamental Tools/Skills must include: (a) CEE 1 Introduction to Environmental Systems Engineering; (b) *at least* one Visual Communication class from CEE 31 Accessing Architecture Through Drawing / CEE 31Q Accessing Architecture Through Drawing, CEE 133F Principles of Freehand Drawing, ME 101 Visual Thinking, ME 110 Design Sketching, ARTSTUDI 160 Intro to Digital / Physical Design, or OSPPARIS 44 EAP: Analytical Drawing and Graphic Art; (c) *at least* one Oral/Written Communication class from ENGR 103 Public Speaking (or ORALCOMM 122 "The TED Commandments": The Art and Heart of Effective Public Speaking), ENGR 202W Technical Writing, or CEE 151 Negotiation, EARTHSYS 195 Natural Hazards and Risk Communication, or EARTHSYS 200 Sustaining Action: Research, Analysis and Writing for the Publicand (d) *at least* one Modeling/Analysis class from CEE 155 Introduction to Sensing Networks for CEE, CEE 120A Building Information Modeling Workshop (or CEE 120S Building Information Modeling Special Study), CEE 146A Engineering Economy, CEE 226 Life Cycle Assessment for Complex Systems, EARTHSYS 144 Fundamentals of Geographic Information Science (GIS), CEE 101D Computations in Civil and Environmental Engineering (if not counted as Math), or CME 211 Software Development for Scientists and Engineers (or EARTHSYS 211 Fundamentals of Modeling).

Urban Environments Focus Area (37 units)

Required		
CEE 100	Managing Sustainable Building Projects	4
CEE 101B	Mechanics of Fluids (or CEE 101N)	4
CEE 176A	Energy Efficient Buildings	3-4
Electives (at least two of the 4 areas below must be included)		
Building Systems		
CEE 102	Legal Principles in Design, Construction, and Project Delivery	3
or		
CEE 131B	Financial Management of Sustainable Urban Systems	3
CEE 130	Architectural Design: 3-D Modeling, Methodology, and Process	4
CEE 156	Building Systems	4
Energy Systems		
CEE 107A	Understanding Energy	3
CEE 176B	Electric Power: Renewables and Efficiency	3-4
ENERGY 171	Energy Infrastructure, Technology and Economics	3
or		
ENERGY 191	Optimization of Energy Systems	3-4
Water Systems		
CEE 166A	Watersheds and Wetlands	3
CEE 166B	Floods and Droughts, Dams and Aqueducts	3
CEE 174A	Providing Safe Water for the Developing and Developed World	3
CEE 174B	Wastewater Treatment: From Disposal to Resource Recovery	3
Urban Planning		
CEE 171	Environmental Planning Methods	3
or		
URBANST 163	Land Use Control	4
CEE 177L	Smart Cities & Communities	2-3
URBANST 113	Introduction to Urban Design: Contemporary Urban Design in Theory and Practice	5
or		
URBANST 164	Sustainable Cities	4-5
or		
URBANST 165	Sustainable Urban and Regional Transportation Planning	4-5
Capstone		
CEE 112A	Industry Applications of Virtual Design & Construction	3-4
CEE 122A	Computer Integrated Architecture/Engineering/ Construction	2
-and-		
CEE 112B	Industry Applications of Virtual Design & Construction	2
CEE 126	International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development	4-5
CEE 141A	Infrastructure Project Development	3
CEE 141B	Infrastructure Project Delivery	3
CEE 221A	Planning Tools and Methods in the Power Sector	3-4
CEE 226E	Advanced Topics in Integrated, Energy-Efficient Building Design	3
CEE 199	Undergraduate Research in Civil and Environmental Engineering	3-4

Freshwater Environments Focus Area (37 units)

Required		
CEE 101B	Mechanics of Fluids (or CEE 101N)	4
CEE 177	Aquatic Chemistry and Biology	4
CEE 166A	Watersheds and Wetlands	3
or		
CEE 174A	Providing Safe Water for the Developing and Developed World	3
Electives		
CEE 160	Mechanics of Fluids Laboratory	2
CEE 161A	Rivers, Streams, and Canals	3-4
CEE 165C	Water Resources Management	3
CEE 166A	Watersheds and Wetlands	3
(if not counted as req'd course)		
CEE 166B	Floods and Droughts, Dams and Aqueducts	3
CEE 166D	Water Resources and Water Hazards Field Trips	2
CEE 171	Environmental Planning Methods	3
or		
URBANST 163	Land Use Control	4
CEE 174A	Providing Safe Water for the Developing and Developed World	3
(if not counted as a req'd course)		

CEE 174B	Wastewater Treatment: From Disposal to Resource Recovery	3
CEE 179A	Water Chemistry Laboratory	3
CEE 265A	Sustainable Water Resources Development	3
CEE 265D	Water and Sanitation in Developing Countries	3
BIOHOPK 150H	Ecological Mechanics	3
EARTHSYS 140	The Energy-Water Nexus	3
EARTHSYS 156	Soil and Water Chemistry	1-4
GS 130	Soil Physics and Hydrology	3
OSPAUSTL 25	Freshwater Systems	3
Capstone		
CEE 126	International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development	4-5
CEE 141A	Infrastructure Project Development	3
CEE 169	Environmental and Water Resources Engineering Design	5
CEE 179C	Environmental Engineering Design	5
CEE 199	Undergraduate Research in Civil and Environmental Engineering	3-4

Coastal Environments Focus Area (36 units)

Required		
CEE 101B	Mechanics of Fluids (or CEE 101N)	4
CEE 164	Introduction to Physical Oceanography	4
CEE 175A	California Coast: Science, Policy, and Law	3-4
Electives		
CEE 160	Mechanics of Fluids Laboratory	2
CEE 166A	Watersheds and Wetlands	3
CEE 171	Environmental Planning Methods	3
or		
URBANST 163	Land Use Control	4
CEE 174A	Providing Safe Water for the Developing and Developed World	3
CEE 174B	Wastewater Treatment: From Disposal to Resource Recovery	3
CEE 177	Aquatic Chemistry and Biology	4
CEE 272	Coastal Contaminants	3-4
BIO 30	Ecology for Everyone	4
or		
BIO 43	Plant Biology, Evolution, and Ecology	5
or		
BIOHOPK 172H	Marine Ecology: From Organisms to Ecosystems	5
or		
EARTHSYS 116	Ecology of the Hawaiian Islands	4
or		
OSPAUSTL 10	Coral Reef Ecosystems	3
or		
OSPSANTG 85	Marine Ecology of Chile and the South Pacific	5
Earthsys 8 The Oceans: An Introduction to the Marine Environment (not offered AY 2015-16)		3
or		
GES 8 Oceanography: An Introduction to the Marine Environment (not offered AY 2015-16)		3
or		
BIOHOPK 182H	Stanford at Sea (Oceanography lectures portion only)	4
EARTHSYS 141	Remote Sensing of the Oceans	3-4
EARTHSYS 146B	Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation	3
EARTHSYS 151	Biological Oceanography	3-4
to be taken concurrently with		
EARTHSYS 152	Marine Chemistry	3-4
EARTHSYS 156M	Marine Resource Economics and Conservation	5
Capstone (1 class req'd)		
CEE 126	International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development	4-5
CEE 141A	Infrastructure Project Development	3
CEE 169	Environmental and Water Resources Engineering Design	5
CEE 179C	Environmental Engineering Design	5
CEE 199	Undergraduate Research in Civil and Environmental Engineering	3-4

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

Individually Designed Majors in Engineering (IDMENS)

Completion of the undergraduate program in Individually Designed Majors in Engineering (IDMEN) leads to the conferral of the Bachelor of Science in an Individually Designed Major: (approved title). The approved title of the IDMEN also appears on the transcript.

Mission of the Undergraduate Program in Individually Designed Majors in Engineering

The mission of the undergraduate program in Individually Designed Majors in Engineering (IDMEN) is to provide students with an understanding of engineering principles and the analytical and problem solving, design, and communication skills necessary to be successful in the field. The B.S. for IDMENs is intended for undergraduates interested in pursuing engineering programs that, by virtue of their focus and intellectual content, cannot be accommodated by existing departmental majors or the pre-approved School of Engineering majors. Core courses in the curriculum include engineering fundamentals, mathematics, technology in society, and the sciences. Students then take additional courses pertinent to their IDMEN major. The program prepares students for careers in government and the corporate sector, and for graduate study.

B.S. in Individually Designed Majors in Engineering

The B.S. degree for IDMENs is intended for undergraduates interested in pursuing engineering programs that, by virtue of their focus and intellectual content, cannot be accommodated by existing departmental majors or the pre-approved School of Engineering majors. IDMEN curricula are designed by students with the assistance of two faculty advisers of their choice and are submitted to the Undergraduate Council's Subcommittee on Individually Designed Majors. The degree conferred is "Bachelor of Science in Individually Designed Major in Engineering: (approved title)."

Students must submit written proposals to the IDMEN subcommittee detailing their course of study. Programs must meet the following requirements: mathematics (21 unit minimum, see Basic Requirement 1 below), science (17 units minimum, see Basic Requirement 2 below), Technology in Society (one approved course, see Basic Requirement 4 below), at least three Engineering Fundamentals courses, see Basic Requirement 4 for a list of courses, and a minimum of 31 units of engineering depth courses, including a capstone depth course with content relevant to proposed goals, and sufficient relevant additional course work to bring the total number of units to at least 90 and at most 107. Students may take additional courses pertinent to their IDMEN major, but the IDMEN proposal itself may not exceed 107 units. Students are responsible for completing the prerequisites for all courses included in their majors.

Each proposal should begin with a statement describing the proposed major. In the statement, the student should make clear the motivation for and goal of the major, and indicate how it relates to her or his projected career plans. The statement should specify how the courses to be taken relate to and move the student toward realizing the major's goal. A proposed title for the major should be included. The title approved by the IDMEN Subcommittee is listed on the student's official University transcript and on the diploma in this form: "Individually Designed Major in Subplan", where "Subplan" is the title approved by the IDMEN Subcommittee.

The proposal statement should be followed by a completed Program Sheet listing all the courses comprising the student's IDMEN curriculum, organized by the five categories printed on the sheet (mathematics, science, technology in society, engineering fundamentals, and engineering depth). Normally, the courses selected should comprise a well-coordinated sequence or sequences that provide mastery of important principles and techniques in a well-defined field. In some circumstances, especially if the proposal indicates that the goal of the major is to prepare the student for graduate work outside of engineering, a more general engineering program may be appropriate. A four-year study plan, showing courses to be taken each quarter, should also be included in the student's IDMEN proposal.

The proposal must be signed by two faculty members who certify that they endorse the major as described in the proposal and that they agree to serve as the student's permanent advisers. One of the faculty members, who must be a member of the School of Engineering and of the Academic Council, acts as the student's primary adviser. The proposal must be accompanied by a statement from that person giving an appraisal of the academic value and viability of the proposed major.

Students proposing IDMENs must have at least four quarters of undergraduate work remaining at Stanford after the quarter in which their proposals are first submitted. Any changes in a previously approved major must be endorsed by the advisers and re-approved by the IDMEN subcommittee. A request by a student to make changes in her or his approved curriculum must be made sufficiently far in advance so that, should the request be denied, adequate time remains to complete the original, approved curriculum. Proposals are reviewed and acted upon once a quarter. Planning forms may be obtained from the Handbook for Undergraduate Engineering Programs at http://ughb.stanford.edu. Completed proposals should be submitted to Darlene Lazar in the Office of Student Affairs, Huang Engineering Center, Suite 135. An IDMEN cannot be a student's secondary major.

Management Science and Engineering (MS&E)

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

Requirements

		Units
Mathematics and Science		
All required; see SoE Basic Requirements 1 and 2 [1]		
CME 100	Vector Calculus for Engineers	5
or MATH 51	Linear Algebra and Differential Calculus of Several Variables	
CME 103	Introduction to Matrix Methods	5
MSE 120	Probabilistic Analysis	5
MSE 121	Introduction to Stochastic Modeling	4
MSE 125	Introduction to Applied Statistics	4
Select one of the following sequences:		8
CHEM 31B & CHEM 33	Chemical Principles II and Structure and Reactivity	
CHEM 31X & CHEM 33	Chemical Principles Accelerated and Structure and Reactivity	
PHYSICS 21 & PHYSICS 22 & PHYSICS 23 & PHYSICS 24	Mechanics Fluids and Heat and Mechanics Fluids and Heat Laboratory and Electricity, Magnetism, and Optics and Electricity, Magnetism and Optics Laboratory	
PHYSICS 41 & PHYSICS 43	Mechanics and Electricity and Magnetism	
Electives from SoE approved list or AP/IB credit [1]		13
Technology in Society		
Select one of the following; see SoE Basic Requirement 4		3
COMM 120W	Digital Media in Society	
COMM 169	Computers and Interfaces	
CS 181	Computers, Ethics, and Public Policy	
ENGR 129		
ENGR 130	Science, Technology, and Contemporary Society	
ENGR 131	Ethical Issues in Engineering	
MSE 181	Issues in Technology and Work for a Postindustrial Economy	
MSE 193	Technology and National Security (WIM)	
MSE 197	Ethics, Technology, and Public Policy (WIM)	
STS 1	The Public Life of Science and Technology	
Engineering Fundamentals [2]		
Three courses; see SoE Basic Requirement 3		
CS 106A	Programming Methodology [3]	5
Select one of the following:		3
ENGR 25B	Biotechnology	
or ENGR 25E	Energy: Chemical Transformations for Production, Storage, and Use	
ENGR 40	Introductory Electronics	
or ENGR 40A	Introductory Electronics	
or ENGR 40M	An Intro to Making: What is EE	
or ENGR 40P	Physics of Electrical Engineering	
ENGR 80	Introduction to Bioengineering (Engineering Living Matter)	
Select one of the following (or ENGR 25, ENGR 40, or ENGR 80 if not used above):		3
ENGR 10	Introduction to Engineering Analysis	
ENGR 14	Intro to Solid Mechanics	
ENGR 15	Dynamics	
ENGR 20	Introduction to Chemical Engineering	
ENGR 30	Engineering Thermodynamics	
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis	
or ENGR 50E	Introduction to Materials Science, Energy Emphasis	
or ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis	
ENGR 60	Engineering Economy	
ENGR 90	Environmental Science and Technology	

		Units
Engineering Depth [2]		
Core Courses (all six required)		25
CS 103	Mathematical Foundations of Computing [4]	
or CS 106B	Programming Abstractions	
or CS 106X	Programming Abstractions (Accelerated)	
ECON 50	Economic Analysis I	
MSE 108	Senior Project	
MSE 111	Introduction to Optimization [4]	
MSE 140	Accounting for Managers and Entrepreneurs	
or MSE 140X	Financial Accounting Concepts and Analysis	
MSE 180	Organizations: Theory and Management	
Area Courses (see below)		27
Choose four or five courses (minimum 15 units) from a primary area and two courses (minimum 6 units) from each of the other two areas.		

Depth Areas

		Units
Finance and Decision Area		6-15
Students choosing F&D as their primary area must take at least two of ECON 51, MS&E 145, and MS&E 152		
Introductory (appropriate for freshmen and sophomores)		
MSE 152	Introduction to Decision Analysis (WIM)	
Intermediate (appropriate for juniors and seniors)		
MSE 145	Introductory Financial Analysis	
MSE 146	Corporate Financial Management	
MSE 245G	Finance for Non-MBAs	
MSE 252	Decision Analysis I: Foundations of Decision Analysis	
Advanced (intended primarily for graduate students)		
MSE 245A	Investment Science	
MSE 246	Financial Risk Analytics	
MSE 250A	Engineering Risk Analysis	
MSE 250B	Project Course in Engineering Risk Analysis	
MSE 245B	Advanced Investment Science	
Operations and Analytics Area		6-15
Students choosing O&A as their primary area may also include CS 161, CS 229, and STATS 202 in their selections [4]		
Introductory (no prerequisites)		
MSE 107	Interactive Management Science	
Methods		
MSE 112	Mathematical Programming and Combinatorial Optimization	
MSE 135	Networks	
MSE 223	Simulation	
MSE 226	"Small" Data	
MSE 231	Introduction to Computational Social Science	
MSE 251	Stochastic Control	
Applications		
MSE 130	Information Networks and Services	
MSE 233	Networked Markets	
MSE 235	Analytics in Action	
MSE 260	Introduction to Operations Management	
MSE 262	Supply Chain Management	
MSE 263	Healthcare Operations Management	
MSE 264	Sustainable Product Development and Manufacturing	
MSE 268	Operations Strategy	
Organizations, Technology, and Policy Area		6-15
Students choosing OT&P as their primary area must take at least two of ENGR 145, MS&E 175, MS&E 181, MS&E 185, PSYCH 70, and SOC 114 (but not both PSYCH 70 and SOC 114) [4]		
Introductory (no prerequisites)		
ENGR 131	Ethical Issues in Engineering [4]	
MSE 178	The Spirit of Entrepreneurship	
MSE 189	Social Networks - Theory, Methods, and Applications	
MSE 190	Methods and Models for Policy and Strategy Analysis	
MSE 193	Technology and National Security (WIM) [4]	
MSE 197	Ethics, Technology, and Public Policy (WIM) [4]	
Advanced (has prerequisites and/or appropriate for juniors and seniors)		
ENGR 145	Technology Entrepreneurship	
MSE 175	Innovation, Creativity, and Change	
MSE 177	Creativity Rules	
MSE 181	Issues in Technology and Work for a Postindustrial Economy [4]	
MSE 183	Leadership in Action	
MSE 185	Global Work	
MSE 243	Energy and Environmental Policy Analysis	
MSE 292	Health Policy Modeling	
MSE 294	Climate Policy Analysis	
MSE 295	Energy Policy Analysis	

1. Math and Science must total a minimum of 44 units. Electives must come from the School of Engineering approved list, or, PSYCH 50 Introduction to Cognitive Neuroscience, or PSYCH 70 Introduction to Social Psychology, and may not repeat material from any other requirement. AP/IB credit for Chemistry, Mathematics, and Physics may be used.
2. Engineering fundamentals plus engineering depth must total a minimum of 60 units.
3. Students may petition to place out of CS 106A Programming Methodology.
4. Courses used to satisfy the Math, Science, Technology in Society, or Engineering Fundamental requirement may not also be used to satisfy an engineering depth requirement.

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

Materials Science and Engineering (MATSCI)

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

Mission of the Undergraduate Program in Materials Science and Engineering

The mission of the undergraduate program in Materials Science and Engineering is to provide students with a strong foundation in materials science and engineering with emphasis on the fundamental scientific and engineering principles which underlie the knowledge and implementation of material structure, processing, properties, and performance of all classes of materials used in engineering systems. Courses in the program develop students' knowledge of modern materials science and engineering, teach them to apply this knowledge analytically to create effective and novel solutions to practical problems, and develop their communication skills and ability to work collaboratively. The program prepares students for careers in industry and for further study in graduate school.

The B.S. in Materials Science and Engineering provides training for the materials engineer and also preparatory training for graduate work in materials science. Capable undergraduates are encouraged to take at least one year of graduate study to extend their course work through the coterminal degree program which leads to an M.S. in Materials Science and Engineering. Coterminal degree programs are encouraged both for undergraduate majors in Materials Science and Engineering and for undergraduate majors in related disciplines.

Requirements

		Units
Mathematics		
20 units minimum; see Basic Requirement 1 [1]		
Select one of the following:		5
MATH 51	Linear Algebra and Differential Calculus of Several Variables	
CME 100/ ENGR 154	Vector Calculus for Engineers	
Select one of the following:		5
MATH 52	Integral Calculus of Several Variables	
CME 104/ ENGR 155B	Linear Algebra and Partial Differential Equations for Engineers	
Select one of the following:		5
MATH 53	Ordinary Differential Equations with Linear Algebra	
CME 102/ ENGR 155A	Ordinary Differential Equations for Engineers	
One additional course		5
Science		
20 units minimum; see Basic Requirement 2 [2]		20
Must include a full year of physics or chemistry, with one quarter of study in the other subject.		
Technology in Society		
One course; see Basic Requirement 3 [3]		3-5
Engineering Fundamentals		
Three courses minimum; see Basic Requirement 4 [4]		
Select one of the following:		4
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis [4]	
ENGR 50E	Introduction to Materials Science, Energy Emphasis [4]	
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis [4]	
At least two additional courses		6-9
Materials Science and Engineering Depth		
Materials Science Fundamentals:		
MATSCI 153	Nanostructure and Characterization	4
MATSCI 154	Thermodynamic Evaluation of Green Energy Technologies [5]	4
MATSCI 155	Nanomaterials Synthesis	4
MATSCI 157	Quantum Mechanics of Nanoscale Materials	4
Two of the following courses:		8
MATSCI 151	Microstructure and Mechanical Properties	
MATSCI 152	Electronic Materials Engineering	
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
MATSCI 190	Organic and Biological Materials	
MATSCI 192	Materials Chemistry	
MATSCI 193	Atomic Arrangements in Solids	
MATSCI 194	Thermodynamics and Phase Equilibria	
MATSCI 195	Waves and Diffraction in Solids	
MATSCI 196	Defects in Crystalline Solids	
MATSCI 197	Rate Processes in Materials	
MATSCI 198	Mechanical Properties of Materials	
MATSCI 199	Electronic and Optical Properties of Solids	
Engineering Depth		16
One of the following courses:		
MATSCI 161	Nanocharacterization Laboratory (WIM)	
MATSCI 164	Electronic and Photonic Materials and Devices Laboratory (WIM)	
Three of the following courses:		
MATSCI 160	Nanomaterials Laboratory	
MATSCI 162	X-Ray Diffraction Laboratory	
MATSCI 163	Mechanical Behavior Laboratory	
MATSCI 165	Nanoscale Materials Physics Computation Laboratory	
Focus Area Options [6]		10

1. Basic Requirement 1 (20 units minimum): see a list of approvedMath Courses (http://www.stanford.edu/group/ughb/cgi-bin/handbook/index.php/Approved_Courses).
2. Basic Requirement 2 (20 units minimum): see a list of approvedScience Courses (http://www.stanford.edu/group/ughb/cgi-bin/handbook/index.php/Approved_Courses).
3. Basic Requirement 3 (one course minimum): see a list of approvedTechnology in Society Courses (http://www.stanford.edu/group/ughb/cgi-bin/handbook/index.php/Approved_Courses).
4. Basic Requirement 4 (3 courses minimum): see a list of approvedEngineering Fundamentals (http://www.stanford.edu/group/ughb/cgi-bin/handbook/index.php/Approved_Courses)Courses. If bothENGR 50 (p. 1) Introduction to Materials Science, Nanotechnology Emphasis,ENGR 50E (p. 1) Introduction to Materials Science - Energy Emphasis, and/orENGR 50M (p. 1) Introduction to Materials Science, Biomaterials Emphasisare taken, one may be used for the Materials Science Fundamentals requirement.
5. ENGR 30 (p. 1) Engineering Thermodynamicsmay be substituted forMATSCI 154 (p. 1) Thermodynamic Evaluation of Green Energy Technologiesas long as the total MATSCI program units total 50 or more.
6. Focus Area Options: 10 units from one of the following Focus Area Options below.

Focus Area Options

Bioengineering (10 units minimum)	
BIOE 220	Introduction to Imaging and Image-based Human Anatomy
BIOE 281	Biomechanics of Movement
BIOE 284B	Cardiovascular Bioengineering
BIOE 333	Interfacial Phenomena and Bionanotechnology

BIOE 381	Orthopaedic Bioengineering
MATSCI 190	Organic and Biological Materials
MATSCI 380	Nano-Biotechnology
MATSCI 381	Biomaterials in Regenerative Medicine
MATSCI 382	Biochips and Medical Imaging
Chemical Engineering (10 units minimum)	
CHEM 171	Physical Chemistry I
CHEMENG 130	Separation Processes
CHEMENG 140	Micro and Nanoscale Fabrication Engineering
CHEMENG 150	Biochemical Engineering
CHEMENG 160	Polymer Science and Engineering
Chemistry (10 units minimum)	
CHEM 151	Inorganic Chemistry I
CHEM 153	Inorganic Chemistry II
CHEM 171	Physical Chemistry I
CHEM 173	Physical Chemistry II
CHEM 175	Physical Chemistry III
CHEM 181	Biochemistry I
CHEM 183	Biochemistry II
CHEM 185	Biophysical Chemistry
Electronics & Photonics (10 units minimum)	
EE 101A	Circuits I
EE 101B	Circuits II
EE 102A	Signal Processing and Linear Systems I
EE 102B	Signal Processing and Linear Systems II
EE 116	Semiconductor Device Physics
EE 134	Introduction to Photonics
EE 136	Introduction to Nanophotonics and Nanostructures
EE 142	Engineering Electromagnetics (Formerly EE 141)
MATSCI 343	Organic Semiconductors for Electronics and Photonics
Energy Technology (10 units minimum)	
EE 293B	Fundamentals of Energy Processes
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution
MATSCI 302	Solar Cells
MATSCI 303	Principles, Materials and Devices of Batteries
ME 260	Fuel Cell Science and Technology
Materials Characterization Techniques (10 units minimum)	
MATSCI 320	Nanocharacterization of Materials
MATSCI 321	Transmission Electron Microscopy
MATSCI 322	Transmission Electron Microscopy Laboratory
MATSCI 323	Thin Film and Interface Microanalysis
MATSCI 326	X-Ray Science and Techniques
Mechanical Behavior & Design (10 units minimum)	
AA 240A	Analysis of Structures
AA 240B	Analysis of Structures
AA 256	Mechanics of Composites
MATSCI 198	Mechanical Properties of Materials
MATSCI 358	Fracture and Fatigue of Materials and Thin Film Structures
ME 80	Mechanics of Materials
or CEE 101A	Mechanics of Materials
ME 203	Design and Manufacturing
ME 294	
Nanoscience (10 units minimum)	
BIOE 333	Interfacial Phenomena and Bionanotechnology
EE 136	Introduction to Nanophotonics and Nanostructures
ENGR 240	Introduction to Micro and Nano Electromechanical Systems
MATSCI 316	Nanoscale Science, Engineering, and Technology
MATSCI 320	Nanocharacterization of Materials
MATSCI 346	Nanophotonics
MATSCI 347	Introduction to Magnetism and Magnetic Nanostructures
MATSCI 380	Nano-Biotechnology
Physics (10 units minimum)	
PHYSICS 70	Foundations of Modern Physics
PHYSICS 110	Advanced Mechanics
PHYSICS 120	Intermediate Electricity and Magnetism I
PHYSICS 121	Intermediate Electricity and Magnetism II
PHYSICS 130	Quantum Mechanics I
PHYSICS 131	Quantum Mechanics II
PHYSICS 134	Advanced Topics in Quantum Mechanics
PHYSICS 170	Thermodynamics, Kinetic Theory, and Statistical Mechanics I
PHYSICS 171	Thermodynamics, Kinetic Theory, and Statistical Mechanics II
PHYSICS 172	Solid State Physics
Self-Defined Option (10 units minimum)	
Petition for a self-defined cohesive program.	

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

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 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.

Requirements

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		16
Science		
20 units minimum; see Basic Requirement 2 [1]		
CHEM 31X	Chemical Principles Accelerated	5
or ENGR 31	Chemical Principles with Application to Nanoscale Science and Technology	
Plus addtional required courses [1]		15
Technology in Society		
One course from approved SoE list; see Basic Requirement 4		3-5
Engineering Fundamentals		
Three courses minimum; see Basic Requirement 3 [2]		
ENGR 40	Introductory Electronics	5
ENGR 70A	Programming Methodology (same as CS 106A)	5
Fundamentals Elective [2]		3-5
Engineering Depth		
Minimum of 68 Engineering Science and Design ABET units; see Basic Requirement 5		
ENGR 14	Intro to Solid Mechanics	4
ENGR 15	Dynamics	4
ENGR 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	4
ME 80	Mechanics of Materials	4
ME 101	Visual Thinking	4
ME 103D	Engineering Drawing and Design [3]	1
ME 112	Mechanical Systems Design [4]	4
ME 113	Mechanical Engineering Design	4
ME 131A	Heat Transfer	3-5
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	4
ME 140	Advanced Thermal Systems [4]	5
ME 161	Dynamic Systems, Vibrations and Control	4
ME 203	Design and Manufacturing [3]	4

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 or ENGR 31 Chemical Principles with Application to Nanoscale Science and Technology are recommended.

2 ME Fundamental elective may not be a course counted for other requirements. Students may opt to use ENGR 14 Intro to Solid Mechanics, ENGR 15 Dynamics, or ENGR 30 Engineering Thermodynamics from the required depth courses as the third fundamental class. However, total units for Engineering Topics (Fundamentals + Depth) must be a minimum of 68 units; additional options courses may be required to meet unit requirements. ENGR 70A (CS 106A) must be taken for 5 units.

3 Courses ME 103D and ME 203 must be taken concurrently .

4 ME 112, ME 131A and ME 140 together fulfill the WIM requirement.

Options to complete the ME depth sequence: see the list of options in the ME major section of the Handbook for Undergraduate Engineering Programs (http://ughb.stanford.edu).

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

Product Design (PD)

Completion of the undergraduate program in Product Design leads to the conferral of the Bachelor of Science in Engineering. The subplan "Product Design" appears on the transcript and on the diploma.

Mission of the Undergraduate Program in Product Design

The mission of the undergraduate program in Product Design is to graduate designers who can synthesize technology, human factors, and business factors in the service of human need. The program teaches a design process that encourages creativity, craftsmanship, aesthetics, and personal expression, and emphasizes brainstorming and need finding. The course work provides students with the skills necessary to carry projects from initial concept to completion of working prototypes. Students studying product design follow the basic mechanical engineering curriculum and are expected to meet the University requirements for a Bachelor of Science degree. The program prepares students for careers in industry and for graduate study.

Conferral of the undergraduate program in Product Design leads to the conferral of the Bachelor of Science in Engineering. The subplan "Product Design" appears on the transcript and on the diploma.

Requirements

		Units
Mathematics and Science		43 minimum
Mathematics		20
20 units minimum		
Recommended: one course in Statistics		
Science		23 units minumum
23 units minimum: 8 units of social science (inc PSYCH 1) and 15 units must be from School of Engineering approved list [1]		
PHYSICS 41	Mechanics	4
PHYSICS 43	Electricity and Magnetism	4
PHYSICS 45	Light and Heat	4
PSYCH 1	Introduction to Psychology	5
PSYCH elective from courses numbered 30-200 [1]		3-5
Technology in Society		
Choose one from SoE Approved TiS Courses list at <ughb.stanford.edu>.		
Engineering Fundamentals		11 units minimum
ENGR 40	Introductory Electronics	3-5
or ENGR 40A	Introductory Electronics	
or ENGR 40M	An Intro to Making: What is EE	
ENGR 70A	Programming Methodology	5
Fundamentals Elective [2]		3-4

Product Design Engineering Depth		55 units minimum
Three Art Studio courses numbered 100 or higher		12
ENGR 14	Intro to Solid Mechanics [3]	4
ME 80	Mechanics of Materials	4
ME 101	Visual Thinking [3]	4
ME 103D	Engineering Drawing and Design [4]	1
ME 110	Design Sketching	2
ME 112	Mechanical Systems Design [5]	4
ME 115A	Introduction to Human Values in Design	3
ME 115B	Product Design Methods	3
ME 115C	Design and Business Factors [6]	3
ME 203	Design and Manufacturing [4]	4
ME 216A	Advanced Product Design: Needfinding	4
ME 216B	Advanced Product Design: Implementation 1	4
ME 216C	Advanced Product Design: Implementation 2	4

1 School of Engineering approved science list available at http://ughb.stanford.edu. If the Psychology elective was taken prior to the requirement being increased to 3 units minimum in 2012-13, student will be short 1 unit in Science/Behavioral Science; this is approved without petition.

2 Select one of the following: ENGR 10, ENGR 15, ENGR 20, ENGR 25B or ENGR 25E, ENGR 30, ENGR 50 or ENGR 50E or ENGR 50M, ENGR 60, ENGR 62, ENGR 90. Note that CS 106B or CS 106X are not allowed to fulfill elective.

3 If ENGR 14 and/or ME 110 were taken prior to the courses being offered for 4 units, depth total may be reduced by 1-2 units with no petition required.

4 ME 103D and ME 203 should be taken concurrently.

5 ME 112 meets the Writing in the Major (WIM) requirement for Product Design.

6 ME 115C is the only course that can be waived if student takes a quarter overseas. Students should plan their overseas quarter to take place in Sophomore year, or Spring Quarter of the junior year only. Total depth units are reduced by 3; this is approved without petition.

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

The joint major program (JMP), authorized by the Academic Senate for a pilot period of six years beginning in 2014-15, permits students to major in both Computer Science and one of ten Humanities majors. See the "Joint Major Program (http://exploredegrees.stanford.edu/undergraduatedegreesandprograms/#jointmajortext)" section of this bulletin for a description of University requirements for the JMP. See also the Undergraduate Advising and Research JMP web site and its associated FAQs.

Students completing the JMP receive a B.A.S. (Bachelor of Arts and Science).

Because the JMP is new and experimental, changes to procedures may occur; students are advised to check the relevant section of the bulletin periodically.

Mission

The Joint Major provides a unique opportunity to gain mastery in two disciplines: Computer Science and a selected humanities field. Unlike the double major or dual major, the Joint Major emphasizes integration of the two fields through a cohesive, transdisciplinary course of study and integrated capstone experience. The Joint Major not only blends the intellectual traditions of two Stanford departments-it does so in a way that reduces the total unit requirement for each major.

Computer Science Major Requirements in the Joint Major Program

(See the respective humanities department Joint Major Program section of this bulletin for details on humanities major requirements.)

The CS requirements for the Joint Major follow the CS requirements for the CS-BS degree with the following exceptions:

1. Two of the depth electives are waived. The waived depth electives are listed below for each CS track.
2. The Senior Project is fulfilled with a joint capstone project. The student enrolls in CS191 or 191W (3 units) during the senior year. Depending on the X department, enrollment in an additional Humanities capstone course may also be required. But, at a minimum, 3 units of CS191 or 191W must be completed.
3. There is no double-counting of units between majors. If a course is required for both the CS and Humanities majors, the student will work with one of the departments to identify an additional course - one which will benefit the academic plan - to apply to that major's total units requirement.
4. For CS, WIM can be satisfied with CS181W or CS191W.

Depth Electives for CS Tracks for students completing a Joint Major:

Artificial Intelligence Track:

One Track Elective (rather than three).

Biocomputation Track:

One course from Note 3 of the Department Program Sheet, plus one course from Note 4 of the Program Sheet..

Computer Engineering Track:

- EE 108A and 108B
- One of the following: EE 101A, 101B, 102A, 102B
- Satisfy the requirements of one of the following concentrations:

1. Digital Systems Concentration: CS 140 or 143; EE 109, 271; plus one of CS 140 or 143 (if not counted above), 144, 149, 240E, 244: EE 273, 282
2. Robotics and Mechatronics Concentration: CS 205A, 223A; ME 210; ENGR 105
3. Networking Concentration: CS 140, 144; plus two of the following, CS 240, 240E, 244, 244B, 244E, 249A, 249B, EE 179, EE 276

Graphics Track:

No Track Electives required (rather than two)

HCI Track:

No Interdisciplinary HCI Electives required

Information Track:

One Track Elective (rather than three)

Systems Track:

One Track Elective (rather than three)

Theory Track:

One Track Elective (rather than three)

Unspecialized Track:

No Track Electives required (rather than two)

Individually Designed Track:

Proposals should include a minimum of five (rather than seven) courses, at least four of which must be CS courses numbered 100 or above.

Declaring a Joint Major Program

To declare the joint major, students must first declare each major through Axess, and then submit the Declaration or Change of Undergraduate Major, Minor, Honors, or Degree Program. (http://studentaffairs.stanford.edu/sites/default/files/registrar/files/change_UG_program.pdf) The Major-Minor and Multiple Major Course Approval Form (http://studentaffairs.stanford.edu/sites/default/files/registrar/files/MajMin_MultMaj.pdf) is required for graduation for students with a joint major.

Dropping a Joint Major Program

To drop the joint major, students must submit the Declaration or Change of Undergraduate Major, Minor, Honors, or Degree Program. (http://studentaffairs.stanford.edu/sites/default/files/registrar/files/change_UG_program.pdf) . Students may also consult the Student Services Center (http://studentaffairs.stanford.edu/studentservicescenter) with questions concerning dropping the joint major.

Transcript and Diploma

Students completing a joint major graduate with a B.A.S. degree. The two majors are identified on one diploma separated by a hyphen. There will be a notation indicating that the student has completed a "Joint Major". The two majors are identified on the transcript with a notation indicating that the student has completed a "Joint Major".

Minor in the School of Engineering

An undergraduate minor in some Engineering programs may be pursued by interested students; see the Handbook for Undergraduate Engineering Programs, or consult with a department's undergraduate program representative or the Office of Student Affairs, Huang Engineering Center, Suite 135.

General requirements and policies for a minor in the School of Engineering are:

1. A set of courses totaling not less than 20 and not more than 36 units, with a minimum of six courses of at least 3 units each. These courses must be taken for a letter grade except where letter grades are not offered, and a minimum GPA of 2.0 within the minor course list must be maintained (departments may require a higher GPA if they choose).
2. The set of courses should be sufficiently coherent as to present a body of knowledge within a discipline or subdiscipline.
3. Prerequisite mathematics, statistics, or science courses, such as those normally used to satisfy the school's requirements for a department major, may not be used to satisfy the requirements of the minor; conversely, engineering courses that serve as prerequisites for subsequent courses must be included in the unit total of the minor program.
4. Courses used for the major and/or minor core must not be duplicated within any other of the student's degree programs; that is, students may not overlap (double-count) courses for completing major and minor requirements except in the case of prerequisite courses as noted in #3.

Departmentally based minor programs are structured at the discretion of the sponsoring department, subject only to requirements 1, 2, 3, and 4 above. Interdisciplinary minor programs may be submitted to the Undergraduate Council for approval and sponsorship. A general Engineering minor is not offered.

Aeronautics and Astronautics (AA) Minor

The Aero/Astro minor introduces undergraduates to the key elements of modern aerospace systems. Within the minor, students may focus on aircraft, spacecraft, or disciplines relevant to both. The course requirements for the minor are described in detail below. Courses cannot be double-counted within a major and a minor, or within multiple minors; if necessary, the Aero/Astro adviser can help select substitute courses to fulfill the AA minor core.

The following core courses fulfill the minor requirements:

		Units
AA 100	Introduction to Aeronautics and Astronautics	3
ENGR 14	Intro to Solid Mechanics *	4
ENGR 15	Dynamics *	4
ENGR 30	Engineering Thermodynamics *	3
ME 70	Introductory Fluids Engineering	4
ME 131A	Heat Transfer [1]	3
Two courses from one of the upper-division elective areas below (min. 6 units)		
Plus one course from a second area below (min. 3 units)		9-11
Aerospace Systems Synthesis/Design		
AA 236A & AA 236B	Spacecraft Design and Spacecraft Design Laboratory	
AA 241A & AA 241B	Introduction to Aircraft Design, Synthesis, and Analysis and Introduction to Aircraft Design, Synthesis, and Analysis	
AA 284B	Propulsion System Design Laboratory	
Dynamics and Controls		
AA 242A	Classical Dynamics	
AA 203	Introduction to Optimal Control Theory	
AA 222	Introduction to Multidisciplinary Design Optimization	
AA 271A	Dynamics and Control of Spacecraft and Aircraft	
ENGR 105	Feedback Control Design	
ENGR 205	Introduction to Control Design Techniques	
Fluids		
AA 200	Applied Aerodynamics	
AA 201A	Fundamentals of Acoustics	
AA 210A	Fundamentals of Compressible Flow	
AA 214A/ CME 207	Numerical Methods in Engineering and Applied Sciences	
AA 283	Aircraft and Rocket Propulsion	
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	
ME 140	Advanced Thermal Systems	

Structures		
AA 240A	Analysis of Structures	
AA 240B	Analysis of Structures	
AA 256	Mechanics of Composites	
AA 280	Smart Structures	
ME 335A	Finite Element Analysis	

* ENGR 14 Intro to Solid Mechanics, ENGR 15 Dynamics, or ENGR 30 Engineering Thermodynamics are waived as minor requirements if already taken as part of the major.

1 AA minors take ME 131 for 3 units

Chemical Engineering (CHE) Minor

The following core courses fulfill the minor requirements:

		Units
ENGR/ CHEMENG 20	Introduction to Chemical Engineering	3
CHEMENG 100	Chemical Process Modeling, Dynamics, and Control	3
CHEMENG 110	Equilibrium Thermodynamics	3
CHEMENG 120A	Fluid Mechanics	4
CHEMENG 120B	Energy and Mass Transport	4
CHEMENG 170	Kinetics and Reactor Design	3
CHEMENG 185A	Chemical Engineering Laboratory A	4
CHEM 171	Physical Chemistry I	3
CHEMENG 180	Chemical Engineering Plant Design	4
Select one of the following:		3
CHEMENG 140	Micro and Nanoscale Fabrication Engineering	
CHEMENG 142	Basic Principles of Heterogeneous Catalysis with Applications in Energy Transformations	
CHEMENG 160	Polymer Science and Engineering	
CHEMENG 162	Polymers for Clean Energy and Water	
CHEMENG 174	Environmental Microbiology I	
CHEMENG 181	Biochemistry I	
Total Units		**34**

Civil Engineering (CE) Minor

The civil engineering minor is intended to give students a focused introduction to one or more areas of civil engineering. Departmental expertise and undergraduate course offerings are available in the areas of Architectural Design, Construction Engineering and Management, and Structural and Geotechnical Engineering. Students interested in Environmental and Water Studies should refer to the Environmental Systems Engineering minor.

The minimum prerequisite for a civil engineering minor is MATH 42 Calculus(or MATH 21 Calculus); however, many courses of interest require PHYSICS 41 Mechanics and/or MATH 51 Linear Algebra and Differential Calculus of Several Variables as prerequisites. The minimum prerequisite for a Civil Engineering minor focusing on architectural design is MATH 41 Calculus (or MATH 19 Calculus) and a course in Statistics. Students should recognize that a minor in civil engineering is not an ABET-accredited degree program.

Since undergraduates having widely varying backgrounds may be interested in obtaining a civil engineering minor, and the field itself is so broad, no single set of course requirements will be appropriate for all students. Instead, interested students are encouraged to propose their own set of courses within the guidelines listed below. Additional information, including example minor programs, are provided on the CEE web site (http://cee.stanford.edu/prospective/undergrad/minor_overview.html) and in Chapter 6 of the Handbook for Undergraduate Engineering Programs (http://ughb.stanford.edu).

General guidelines are:

1. A civil engineering minor must contain at least 24 units of course work not taken for the major, and must consist of at least six classes of at least 3 units each of letter-graded work, except where letter grades are not offered.
2. The list of courses must represent a coherent body of knowledge in a focused area, and should include classes that build upon one another. Example programs are given on the CEE webpage.

Professor Anne Kiremidjian (kiremidjian@stanford.edu) is the CEE undergraduate minor adviser in Structural Engineering and Construction Engineering and Management. John Barton (jhbarton@stanford.edu), Program Director for Architectural Design, is the undergraduate minor adviser in Architectural Design. Students must consult the appropriate adviser when developing their minor program, and obtain approval of the finalized study list from them.

Computer Science (CS) Minor

The following core courses fulfill the minor requirements. Prerequisites include the standard mathematics sequence through MATH 51.

		Units
Introductory Programming (AP Credit may be used to fulfill this requirement):		
CS 106B	Programming Abstractions	5
or CS 106X	Programming Abstractions (Accelerated)	
Core:		
CS 103	Mathematical Foundations of Computing	5
CS 107	Computer Organization and Systems	5
or CS 107E	Computer Systems from the Ground Up	
CS 109	Introduction to Probability for Computer Scientists	5
Electives (choose two courses from different areas):		
Artificial Intelligence—		
CS 124	From Languages to Information	4
CS 221	Artificial Intelligence: Principles and Techniques	4
CS 229	Machine Learning	3-4
Human-Computer Interaction—		
CS 147	Introduction to Human-Computer Interaction Design	4
Software—		
CS 108	Object-Oriented Systems Design	4
CS 110	Principles of Computer Systems	5
Systems—		
CS 140	Operating Systems and Systems Programming	4
CS 143	Compilers	4
CS 144	Introduction to Computer Networking	4
CS 145	Introduction to Databases	4
CS 148	Introduction to Computer Graphics and Imaging	4
Theory—		
CS 154	Introduction to Automata and Complexity Theory	4
CS 157	Logic and Automated Reasoning	3
CS 161	Design and Analysis of Algorithms	5

Note: for students with no programming background and who begin with CS 106A, the minor consists of seven courses.

Electrical Engineering (EE) Minor

The options for completing a minor in EE are outlined below. Students must complete a minimum of 23-25 units, as follows:

		Units
Select one of the following courses:		5
EE 65	Modern Physics for Engineers	
ENGR 40	Introductory Electronics	
ENGR 40M	An Intro to Making: What is EE	
Select one of the following options:		8
Option I:		
EE 101A	Circuits I	
EE 101B	Circuits II	
Option II:		
EE 102A	Signal Processing and Linear Systems I	
EE 102B	Signal Processing and Linear Systems II	
Option III:		
EE 108	Digital System Design	
EE 180	Digital Systems Architecture	
In addition, four letter-graded EE or Related courses at the 100-level or higher must be taken (12 units minimum). CS 107 is required as a prerequisite for EE 180, but can count as one of the four classes.		12

Environmental Systems Engineering (EnvSE) Minor

The Environmental Systems Engineering minor is intended to give students a focused introduction to one or more areas of Environmental Systems Engineering. Departmental expertise and undergraduate course offerings are available in the areas of environmental engineering and science, environmental fluid mechanics and hydrology, and atmosphere/energy. The minimum prerequisite for an Environmental Systems Engineering minor is MATH 42 Calculus (or MATH 21 Calculus); however, many courses of interest require PHYSICS 41 Mechanics and/or MATH 51 Linear Algebra and Differential Calculus of Several Variables as prerequisites. Students should recognize that a minor in Environmental Systems Engineering is not an ABET-accredited degree program.

Since undergraduates having widely varying backgrounds may be interested in obtaining an environmental systems engineering minor, no single set of course requirements is appropriate for all students. Instead, interested students are encouraged to propose their own set of courses within the guidelines listed below. Additional information on preparing a minor program is available in the Undergraduate Engineering Handbook (http://ughb.stanford.edu).

General guidelines are—

- An Environmental Systems Engineering minor must contain at least 24 units of course work not taken for the major, and must consist of at least six classes of at least 3 units each of letter-graded work, except where letter grades are not offered.
- The list of courses must represent a coherent body of knowledge in a focused area, and should include classes that build upon one another. Example programs are available on the CEE web site (http://cee.stanford.edu/prospective/undergrad/minor_overview.html).

Professor Lynn Hildemann (hildemann@stanford.edu) is the CEE undergraduate minor adviser in Environmental Systems Engineering. Students must consult with Professor Hildemann in developing their minor program, and obtain approval of the finalized study list from her.

Management Science and Engineering (MS&E) Minor

The following courses are required to fulfill the minor requirements:

		Units
Background requirements (two courses)		
CME 100	Vector Calculus for Engineers	5
or MATH 51	Linear Algebra and Differential Calculus of Several Variables	
CS 106A	Programming Methodology	5
Minor requirements (seven courses, letter-graded)		
MSE 111	Introduction to Optimization	4
MSE 120	Probabilistic Analysis	5
MSE 121	Introduction to Stochastic Modeling	4
MSE 125	Introduction to Applied Statistics	4
MSE 180	Organizations: Theory and Management	4
Electives (select any two 100- or 200-level MS&E courses)		6
Recommended courses		
In addition to the required background and minor courses, it is recommended that students also take the following courses.		
ECON 50	Economic Analysis I	5
MSE 140	Accounting for Managers and Entrepreneurs (may be used as one of the required electives above)	2-4
or MSE 140X	Financial Accounting Concepts and Analysis	

Materials Science and Engineering (MATSCI) Minor

A minor in Materials Science and Engineering allows interested students to explore the role of materials in modern technology and to gain an understanding of the fundamental processes that govern materials behavior.

The following courses fulfill the minor requirements:

		Units
Engineering Fundamentals		
Select one of the following:		4
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis	
ENGR 50E	Introduction to Materials Science, Energy Emphasis	
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis	
Materials Science Fundamentals and Engineering Depth		
Select six of the following:		24
MATSCI 151	Microstructure and Mechanical Properties	
MATSCI 152	Electronic Materials Engineering	
MATSCI 153	Nanostructure and Characterization	
MATSCI 154	Thermodynamic Evaluation of Green Energy Technologies	
MATSCI 155	Nanomaterials Synthesis	
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
MATSCI 157	Quantum Mechanics of Nanoscale Materials	
MATSCI 160	Nanomaterials Laboratory	
MATSCI 161	Nanocharacterization Laboratory	
MATSCI 162	X-Ray Diffraction Laboratory	
MATSCI 163	Mechanical Behavior Laboratory	
MATSCI 164	Electronic and Photonic Materials and Devices Laboratory	

MATSCI 165	Nanoscale Materials Physics Computation Laboratory	
MATSCI 190	Organic and Biological Materials	
MATSCI 192	Materials Chemistry	
MATSCI 193	Atomic Arrangements in Solids	
MATSCI 194	Thermodynamics and Phase Equilibria	
MATSCI 195	Waves and Diffraction in Solids	
MATSCI 196	Defects in Crystalline Solids	
MATSCI 197	Rate Processes in Materials	
MATSCI 198	Mechanical Properties of Materials	
MATSCI 199	Electronic and Optical Properties of Solids	
Total Units		**28**

Mechanical Engineering (ME) Minor

The following courses fulfill the minor requirements:

		Units
General Minor *		
ENGR 14	Intro to Solid Mechanics	4
ENGR 15	Dynamics	4
ENGR 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	4
ME 101	Visual Thinking	4
Plus two of the following:		8-9
ME 80	Mechanics of Materials	
ME 131A	Heat Transfer	
ME 161	Dynamic Systems, Vibrations and Control	
ME 203	Design and Manufacturing	
Thermosciences Minor **		
ENGR 14	Intro to Solid Mechanics	4
ENGR 30	Engineering Thermodynamics	3
ME 70	Introductory Fluids Engineering	4
ME 131A	Heat Transfer	5
ME 131B	Fluid Mechanics: Compressible Flow and Turbomachinery	4
ME 140	Advanced Thermal Systems	5
Mechanical Design Minor ***		
ENGR 14	Intro to Solid Mechanics	4
ENGR 15	Dynamics	4
ME 80	Mechanics of Materials	4
ME 101	Visual Thinking	4
ME 112	Mechanical Systems Design	4
ME 203	Design and Manufacturing	4
Plus one of the following:		3-4
ME 113	Mechanical Engineering Design	
ME 210	Introduction to Mechatronics	
ME 220	Introduction to Sensors	
Total Units		**79-81**

* This minor aims to expose students to the breadth of ME in terms of topics and analytic and design activities. Prerequisites: MATH 41 Calculus, MATH 42 Calculus, and PHYSICS 41 Mechanics.

** Prerequisites: MATH 41 Calculus, MATH 42 Calculus, MATH 51 Linear Algebra and Differential Calculus of Several Variables (or CME 100 Vector Calculus for Engineers) and PHYSICS 41 Mechanics.

*** This minor aims to expose students to design activities supported by analysis. Prerequisites: MATH 41 Calculus, PHYSICS 42 Classical Mechanics Laboratory, and PHYSICS 41 Mechanics.

Master of Science in the School of Engineering

The M.S. degree is conferred on graduate students in engineering according to the University regulations stated in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin, and is described in the various department listings. A minimum of 45 units is usually required in M.S. programs in the School of Engineering. The presentation of a thesis is not a school requirement. Further information is found in departmental listings.

Master of Science in Engineering

The M.S. in Engineering is available to students who wish to follow an interdisciplinary program of study that does not conform to a normal graduate program in a department. There are three school requirements for the M.S. degree in Engineering:

1. The student's program must be a coherent one with a well-defined objective and must be approved by a department within the school which has experience with graduate-level teaching and advising in the program area.
2. The student's program must include at least 21 units of courses within the School of Engineering with catalog numbers of 200 or above in which the student receives letter grades.
3. The program must include a total of at least 45 units.

Each student's program is administered by the particular department in which it is lodged and must meet the standard of quality of that department. Transfer into this program is possible from any graduate program by application through the appropriate department; the department then recommends approval to the Office of Student Affairs in the School of Engineering. The application should be submitted before completing 18 units of the proposed program; it should include a statement describing the objectives of the program, the coherence of the proposed course work, and why this course of study cannot conform to existing graduate programs. Normally, it would include the approval of at least one faculty member willing to serve as adviser. (A co-advising team may be appropriate for interdisciplinary programs.) The actual transfer is accomplished through the Graduate Authorization Petition process.

The M.S. in Engineering is rarely pursued as a coterminal program, and potential coterms are encouraged to explore the range of master's options in the departments and interdisciplinary programs. In the unusual circumstance of a coterminal application to the M.S. in Engineering, the application process should be the same as described above, using either the Graduate Authorization Petition in Axess (for coterminal students who want to transfer between MS programs) or the the Application for Admission to Coterminal Masters' Program (http://registrar.stanford.edu/pdf/CotermApplic.pdf) (for students who have not yet been admitted to a master's program). The policy for transferring courses taken as an undergraduate prior to coterm admission to the M.S. in Engineering corresponds to the policy of the particular department in which the student's program is lodged and administered. A clear statement of the department's coterminal policy, and how it applies to the applicant within the Master of Science in Engineering program, should be added to the application materials.

Honors Cooperative Program

Industrial firms, government laboratories, and other organizations may participate in the Honors Cooperative Program (HCP), a program that permits qualified engineers, scientists, and technology professionals admitted to Stanford graduate degree programs to register for Stanford courses and obtain the degree on a part-time basis. In many areas of concentration, the master's degree can be obtained entirely online.

Through this program, many graduate courses offered by the School of Engineering on campus are made available through the Stanford Center for Professional Development (SCPD). SCPD delivers more than 250 courses a year online. For HCP employees who are not part of a graduate degree program at Stanford, courses and certificates are also available through a non-degree option (NDO) and a non-credit professional education program. Non-credit short courses may be customized to meet a company's needs. For a full description of educational services provided by SCPD, see http://scpd.stanford.edu; call (650) 725-3000; fax (650) 725-2868; or email scpd-registration@stanford.edu.

Engineer Degree in the School of Engineering

The degree of Engineer is intended for students who want additional graduate training beyond that offered in an M.S. program. The program of study must satisfy the student's department and must include at least 90 units beyond the B.S. degree. The presentation of a thesis is required. The University regulations for the Engineer degree are stated in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin, and further information is available in the individual departmental sections of this bulletin.

Doctor of Philosophy in the School of Engineering

Programs leading to the Ph.D. degree are offered in each of the departments of the school. University regulations for the Ph.D. are given in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin. Further information is found in departmental listings.

Dean: Persis Drell

Senior Associate Deans: Laura L. Breyfogle (External Relations), Scott Calvert (Administration), Bernd Girod (Senior Associate Dean at Large), Thomas Kenny (Student Affairs), Jennifer Widom (Faculty and Academic Affairs)

Associate Dean: Noé P. Lozano (Diversity Programs)

Assistant Dean: Sally Gressens (Graduate Student Affairs)

Faculty Teaching General Engineering Courses

Professors: Chris Edwards, Mark Horowitz, Chaitan Khosla, Sanjay Lall, Parviz Moin, Eric Roberts, Stephen M. Rock, Sheri Sheppard, Robert Sinclair, James Swartz, Hai Wang, Bernard Roth

Associate Professors: : Drew Endy, Sarah Heilshorn, Jan Liphardt, Nick Melosh, Allison Okamura, Amin Saberi, Thomas Jaramillo, Xiaolin Zheng

Assistant Professors: Chuck Eesley, W. Matthias Ihme, Sindy Tang

Professors (Teaching): Thomas H. Byers, Robert McGinn, Eric Roberts, Mehran Sahami

Senior Lecturers: Vadim Khayms

Lecturers: Jeff Epstein, Larry Lagerstrom, Cynthia Bailey Lee, Keith Schwarz, Marty Stepp, Jeremy Utley

Other Teaching: Steve Blank

Overseas Studies Courses in 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
OSPBER 40B	Introductory Electronics	5
OSPBER 50M	Introductory Science of Materials	4
OSPFLOR 50M	Introductory Science of Materials	4
OSPKYOTO 40K	Introductory Electronics	5
OSPPARIS 40P	Introductory Electronics	5
OSPPARIS 50M	Introductory Science of Materials	4

Courses

ENGR 10. Introduction to Engineering Analysis. 4 Units.
Integrated approach to the fundamental scientific principles that are the cornerstones of engineering analysis: conservation of mass, atomic species, charge, momentum, angular momentum, energy, production of entropy expressed in the form of balance equations on carefully defined systems, and incorporating simple physical models. Emphasis is on setting up analysis problems arising in engineering. Topics: simple analytical solutions, numerical solutions of linear algebraic equations, and laboratory experiences. Provides the foundation and tools for subsequent engineering courses. Prerequisite: AP Physics and AP Calculus or equivalent.

ENGR 14. Intro to Solid Mechanics. 4 Units.
Introduction to engineering analysis using the principles of engineering solid mechanics. Builds on the math and physical reasoning concepts in Physics 41 to develop skills in evaluation of engineered systems across a variety of fields. Foundational ideas for more advanced solid mechanics courses such as ME80 or CEE101A. Interactive lecture sessions focused on mathematical application of key concepts, with weekly complementary lab session on testing and designing systems that embody these concepts. Limited enrollment, subject to instructor approval. Pre-requisite: Physics 41.

ENGR 15. Dynamics. 4 Units.
The application of Newton's Laws to solve 2-D and 3-D static and dynamic problems, particle and rigid body dynamics, freebody diagrams, and equations of motion, with application to mechanical, biomechanical, and aerospace systems. Computer numerical solution and dynamic response. Prerequisites: Calculus (differentiation and integration) such as MATH 41; and ENGR 14 (statics and strength) or a mechanics course in physics such as PHYSICS 41.

ENGR 20. Introduction to Chemical Engineering. 4 Units.
Overview of chemical engineering through discussion and engineering analysis of physical and chemical processes. Topics: overall staged separations, material and energy balances, concepts of rate processes, energy and mass transport, and kinetics of chemical reactions. Applications of these concepts to areas of current technological importance: biotechnology, energy, production of chemicals, materials processing, and purification. Prerequisite: CHEM 31.
Same as: CHEMENG 20

ENGR 25B. Biotechnology. 3 Units.
Biology and chemistry fundamentals, genetic engineering, cell culture, protein production, pharmaceuticals, genomics, viruses, gene therapy, evolution, immunology, antibodies, vaccines, transgenic animals, cloning, stem cells, intellectual property, governmental regulations, and ethics. Prerequisites: CHEM 31 and MATH 41 or equivalent courage.
Same as: CHEMENG 25B

ENGR 25E. Energy: Chemical Transformations for Production, Storage, and Use. 3 Units.
An introduction and overview to the challenges and opportunities of energy supply and consumption. Emphasis on energy technologies where chemistry and engineering play key roles. Review of energy fundamentals along with historical energy perspectives and current energy production technologies. In depth analysises of solar thermal systems, biofuels, photovoltaics and electrochemical devices (batteries and fuel cells). Prerequisites: high school chemistry or equivalent.
Same as: CHEMENG 25E

ENGR 30. Engineering Thermodynamics. 3 Units.
The basic principles of thermodynamics are introduced in this course. Concepts of energy and entropy from elementary considerations of the microscopic nature of matter are discussed. The principles are applied in thermodynamic analyses directed towards understanding the performances of engineering systems. Methods and problems cover socially responsible economic generation and utilization of energy in central power generation plants, solar systems, refrigeration devices, and automobile, jet and gas-turbine engines.

ENGR 31. Chemical Principles with Application to Nanoscale Science and Technology. 4 Units.
Preparation for engineering disciplines emphasizing modern technological applications of solid state chemistry. Topics include: crystallography; chemical kinetics and equilibria; thermodynamics of phase changes and reaction; quantum mechanics of chemical bonding, molecular orbital theory, and electronic band structure of crystals; and the materials science of basic electronic and photonic devices. Prerequisite: AP 4 or 5 Chemistry, or equivalent, or successful completion of CHEM 31x placement test, or college chemistry background in stoichiometry, periodicity, Lewis and VSEPR structures, dissolution/precipitation and acid/base reactions, gas laws, and phase behavior.

ENGR 40. Introductory Electronics. 5 Units.
Overview of electronic circuits and applications. Electrical quantities and their measurement, including operation of the oscilloscope. Basic models of electronic components including resistors, capacitors, inductors, and the operational amplifier. Frequency response of linear circuits, including basic filters, using phasor analysis. Digital logic fundamentals, logic gates, and basic combinatorial logic blocks. Lab. Lab assignments. Enrollment limited to 200.

ENGR 40A. Introductory Electronics. 3 Units.
Abbreviated version of E40, for students not pursuing degree in Electrical Engineering. Instruction to be completed in the first seven weeks of the quarter. Overview of electronic circuits and applications. Electrical quantities and their measurement, including operation of the oscilloscope. Basic models of electronic components including resistors, capacitors, inductors, and the operational amplifier. Lab. Lab assignments. Enrollment limited to 200.

ENGR 40M. An Intro to Making: What is EE. 3-5 Units.
Is a hands-on class where students learn to make stuff. Through the process of building, you are introduced to the basic areas of EE. Students build a "useless box" and learn about circuits, feedback, and programming hardware, a light display for your desk and bike and learn about coding, transforms, and LEDs, a solar charger and an EKG machine and learn about power, noise, feedback, more circuits, and safety. And you get to keep the toys you build. Prerequisite: CS 106A.

ENGR 40P. Physics of Electrical Engineering. 5 Units.
How everything from electrostatics to quantum mechanics is used in common high-technology products. Electrostatics are critical in micro-mechanical systems used in many sensors and displays, and Electromagnetic waves are essential in all high-speed communication systems. How to propagate energy on transmission lines, optical fibers,and in free space. Which aspects of modern physics are needed to generate light for the operation of a DVD player or TV. Introduction to semiconductors, solid-state light bulbs, and laser pointers. Hands-on labs to connect physics to everyday experience. Prerequisites: Physics 43.
Same as: EE 41

ENGR 50. Introduction to Materials Science, Nanotechnology Emphasis. 4 Units.
The structure, bonding, and atomic arrangements in materials leading to their properties and applications. Topics include electronic and mechanical behavior, emphasizing nanotechnology, solid state devices, and advanced structural and composite materials.

ENGR 50E. Introduction to Materials Science, Energy Emphasis. 4 Units.
Materials structure, bonding and atomic arrangements leading to their properties and applications. Topics include electronic, thermal and mechanical behavior; emphasizing energy related materials and challenges.

ENGR 50M. Introduction to Materials Science, Biomaterials Emphasis. 4 Units.
Topics include: the relationship between atomic structure and macroscopic properties of man-made and natural materials; mechanical and thermodynamic behavior of surgical implants including alloys, ceramics, and polymers; and materials selection for biotechnology applications such as contact lenses, artificial joints, and cardiovascular stents. No prerequisite.

ENGR 60. Engineering Economy. 3 Units.
Fundamentals of economic analysis. Interest rates, net present value, and internal rate of return. Applications to personal and corporate financial decisions. Mortgage evaluation, insurance decision, hedging/risk reduction, project selection, capital budgeting, and investment valuation. Effects of taxes on personal and business decisions. Investment decisions under uncertainty and utility theory. Please see http://www.stanford.edu/class/engr60. Prerequisites: precalculus and elementary probability.

ENGR 62. Introduction to Optimization. 4 Units.
Formulation and analysis of linear optimization problems. Solution using Excel solver. Polyhedral geometry and duality theory. Applications to contingent claims analysis, production scheduling, pattern recognition, two-player zero-sum games, and network flows. Prerequisite: CME 100 or MATH 51.
Same as: MSE 111

ENGR 70A. Programming Methodology. 3-5 Units.
Introduction to the engineering of computer applications emphasizing modern software engineering principles: object-oriented design, decomposition, encapsulation, abstraction, and testing. Uses the Java programming language. Emphasis is on good programming style and the built-in facilities of the Java language. No prior programming experience required. Summer quarter enrollment is limited. Priority given to Stanford students.
Same as: CS 106A

ENGR 70B. Programming Abstractions. 3-5 Units.
Abstraction and its relation to programming. Software engineering principles of data abstraction and modularity. Object-oriented programming, fundamental data structures (such as stacks, queues, sets) and data-directed design. Recursion and recursive data structures (linked lists, trees, graphs). Introduction to time and space complexity analysis. Uses the programming language C++ covering its basic facilities. Prerequisite: 106A or equivalent. Summer quarter enrollment is limited. Priority given to Stanford students.
Same as: CS 106B

ENGR 70X. Programming Abstractions (Accelerated). 3-5 Units.
Intensive version of 106B for students with a strong programming background interested in a rigorous treatment of the topics at an accelerated pace. Additional advanced material and more challenging projects. Prerequisite: excellence in 106A or equivalent, or consent of instructor.
Same as: CS 106X

ENGR 80. Introduction to Bioengineering (Engineering Living Matter). 4 Units.
Students completing BIOE.80 should have a working understanding for how to approach the systematic engineering of living systems to benefit all people and the planet. Our main goals are (1) to help students learn ways of thinking about engineering living matter and (2) to empower students to explore the broader ramifications of engineering life. Specific concepts and skills covered include but are not limited to: capacities of natural life on Earth; scope of the existing human-directed bioeconomy; deconstructing complicated problems; reaction & diffusion systems; microbial human anatomy; conceptualizing the engineering of biology; how atoms can be organized to make molecules; how to print DNA from scratch; programming genetic sensors, logic, & actuators; biology beyond molecules (photons, electrons, etc.); what constraints limit what life can do?; what will be the major health challenges in 2030?; how does what we want shape bioengineering?; who should choose and realize various competing bioengineering futures?.
Same as: BIOE 80

ENGR 90. Environmental Science and Technology. 3 Units.
Introduction to environmental quality and the technical background necessary for understanding environmental issues, controlling environmental degradation, and preserving air and water quality. Material balance concepts for tracking substances in the environmental and engineering systems.
Same as: CEE 70

ENGR 100. Teaching Public Speaking. 3 Units.
The theory and practice of teaching public speaking and presentation development. Lectures/discussions on developing an instructional plan, using audiovisual equipment for instruction, devising tutoring techniques, and teaching delivery, organization, audience analysis, visual aids, and unique speaking situations. Weekly practice speaking. Students serve as apprentice speech tutors. Those completing course may become paid speech instructors in the Technical Communications Program. Prerequisite: consent of instructor.

ENGR 102W. Writing for Engineers. 3 Units.
Intensive practicum focusing on effective communication of technical,nscientific, and professional information in industry and academia. Bestnwriting practices for varied audiences, purposes, and media. Groupnworkshops and individual conferences with instructors.

ENGR 103. Public Speaking. 3 Units.
Priority to Engineering students. Introduction to speaking activities, from impromptu talks to carefully rehearsed formal professional presentations. How to organize and write speeches, analyze audiences, create and use visual aids, combat nervousness, and deliver informative and persuasive speeches effectively. Weekly class practice, rehearsals in one-on-one tutorials, videotaped feedback. Limited enrollment.

ENGR 105. Feedback Control Design. 3 Units.
Design of linear feedback control systems for command-following error, stability, and dynamic response specifications. Root-locus and frequency response design techniques. Examples from a variety of fields. Some use of computer aided design with MATLAB. Prerequisite: EE 102, ME 161, or equivalent.

ENGR 110. Perspectives in Assistive Technology (ENGR 110). 1-3 Unit.
Seminar and student project course. Explores the medical, social, ethical, and technical challenges surrounding the design, development, and use of technologies that improve the lives of people with disabilities and older adults. Guest lecturers include engineers, clinicians, and individuals with disabilities. Tours of local facilities, assistive technology faire, and movie screening. Juniors, seniors, and graduate students from any discipline welcome. Enrollment limited to class capacity of 45. 1 unit for seminar attendance only (CR/NC) or individual project (letter grade). 3 units for students who pursue a team-based assistive technology project. Projects can be continued as independent study in Spring Quarter. See http://engr110.stanford.edu/. Service Learning Course (certified by Haas Center for Public Service).
Same as: ENGR 210

ENGR 113A. Solar Decathlon 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 213A

ENGR 113B. Solar Decathlon 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 213B

ENGR 113C. Solar Decathlon 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 213C

ENGR 113D. SOLAR DECATHLON 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 213D

ENGR 115. Design the Tech Challenge. 2 Units.
Students work with Tech Museum of San Jose staff to design the Tech Challenge, a yearly engineering competition for 6-12th grade students. Brainstorming, field trips to the museum, prototyping, coaching, and presentations to the Tech Challenge advisory board. See at http://techchallenge.thetech.org. May be repeated for credit.
Same as: ENGR 215

ENGR 118. Cross-Cultural Design for Service. 3 Units.
Students spend the summer in China working collaboratively to use design thinking for a project in the countryside. Students learn and apply the principles of design innovation including user research, ideation, prototyping, storytelling and more in a cross cultural setting to design a product or service that will benefit Chinese villagers. Students should be prepared to work independently in a developing region of China, to deal with persistent ambiguity, and to work with a cross-cultural, diverse team of students on their projects. Applications for Summer 2012 were due in March.

ENGR 120. Fundamentals of Petroleum Engineering. 3 Units.
Lectures, problems, field trip. Engineering topics in petroleum recovery; origin, discovery, and development of oil and gas. Chemical, physical, and thermodynamic properties of oil and natural gas. Material balance equations and reserve estimates using volumetric calculations. Gas laws. Single phase and multiphase flow through porous media.
Same as: ENERGY 120

ENGR 130. Science, Technology, and Contemporary Society. 4-5 Units.
Key social, cultural, and values issues raised by contemporary scientific and technological developments; distinctive features of science and engineering as sociotechnical activities; major influences of scientific and technological developments on 20th-century society, including transformations and problems of work, leisure, human values, the fine arts, and international relations; ethical conflicts in scientific and engineering practice; and the social shaping and management of contemporary science and technology.

ENGR 131. Ethical Issues in Engineering. 4 Units.
Moral rights and responsibilities of engineers in relation to society, employers, colleagues, and clients; cost-benefit-risk analysis, safety, and informed consent; the ethics of whistle blowing; ethical conflicts of engineers as expert witnesses, consultants, and managers; ethical issues in engineering design, manufacturing, and operations; ethical issues arising from engineering work in foreign countries; and ethical implications of the social and environmental contexts of contemporary engineering. Case studies, guest practitioners, and field research. Limited enrollment.

ENGR 140A. Leadership of Technology Ventures. 3-4 Units.
First of three-part sequence for students selected to the Mayfield Fellows Program. Management and leadership within high technology startups, focusing on entrepreneurial skills related to product and market strategy, venture financing and cash flow management, team recruiting and organizational development, and the challenges of managing growth and handling adversity in emerging ventures. Other engineering faculty, founders, and venture capitalists participate as appropriate. Recommended: accounting or finance course (MS&E 140, ECON 90, or ENGR 60).

ENGR 140B. Leadership of Technology Ventures. 1-2 Unit.
Open to Mayfield Fellows only; taken during the summer internship at a technology startup. Students exchange experiences and continue the formal learning process. Activities journal. Credit given following quarter.

ENGR 140C. Leadership of Technology Ventures. 2-3 Units.
Open to Mayfield Fellows only. Capstone to the 140 sequence. Students, faculty, employers, and venture capitalists share recent internship experiences and analytical frameworks. Students develop living case studies and integrative project reports.

ENGR 145. Technology Entrepreneurship. 4 Units.
How do you create a successful start-up? What is entrepreneurial leadership in a large firm? What are the differences between an idea and true opportunity? How does an entrepreneur form a team and gather the resources necessary to create a great enterprise? Mentor-guided project focused on developing students' startup ideas, immersion in nuances of innovation and early stage entrepreneurship, case studies, research on the entrepreneurial process, and the opportunity to network with Silicon Valley's top entrepreneurs and venture capitalists. For undergraduates of all majors who seek to understand the formation and growth of high-impact start-ups in areas such as information, energy, medical and consumer technologies. No prerequisites. Limited enrollment. Please submit Autumn course application at http://goo.gl/forms/fO61GT1NnY by 6pm on Monday, September 21, 2015.

ENGR 150. Data Challenge Lab. 1-6 Unit.
In this lab, students develop the practical skills of data science by solving a series of increasingly difficult, real problems. Skills developed include: data manipulation, exploratory data analysis, data visualization, and predictive modeling. The data challenges each student undertakes are based upon their current skills. Students receive one-on-one coaching and see how expert practitioners solve the same challenges. Limited enrollment; application required. May be repeated for credit. See http://datalab.stanford.edu for more information.

ENGR 154. Vector Calculus for Engineers. 5 Units.
Computation and visualization using MATLAB. Differential vector calculus: analytic geometry in space, functions of several variables, partial derivatives, gradient, unconstrained maxima and minima, Lagrange multipliers. Introduction to linear algebra: matrix operations, systems of algebraic equations, methods of solution and applications. Integral vector calculus: multiple integrals in Cartesian, cylindrical, and spherical coordinates, line integrals, scalar potential, surface integrals, Greeniquest;s, divergence, and Stokesiquest; theorems. Examples and applications drawn from various engineering fields. Prerequisites: 10 units of AP credit (Calc BC with 4 or 5, or Calc AB with 5), or Math 41 and 42. Note: Students enrolled in section 100-02 and 100A-02 are required to attend the discussion sections on Thursdays 5:15-6:45.
Same as: CME 100

ENGR 155A. Ordinary Differential Equations for Engineers. 5 Units.
Analytical and numerical methods for solving ordinary differential equations arising in engineering applications: Solution of initial and boundary value problems, series solutions, Laplace transforms, and nonlinear equations; numerical methods for solving ordinary differential equations, accuracy of numerical methods, linear stability theory, finite differences. Introduction to MATLAB programming as a basic tool kit for computations. Problems from various engineering fields. Prerequisite: 10 units of AP credit (Calc BC with 4 or 5, or Calc AB with 5), or Math 41 and 42. Recommended: CME100.
Same as: CME 102

ENGR 155B. Linear Algebra and Partial Differential Equations for Engineers. 5 Units.
Linear algebra: matrix operations, systems of algebraic equations, Gaussian elimination, undetermined and overdetermined systems, coupled systems of ordinary differential equations, eigensystem analysis, normal modes. Fourier series with applications, partial differential equations arising in science and engineering, analytical solutions of partial differential equations. Numerical methods for solution of partial differential equations: iterative techniques, stability and convergence, time advancement, implicit methods, von Neumann stability analysis. Examples and applications from various engineering fields. Prerequisite: CME 102/ENGR 155A.
Same as: CME 104

ENGR 155C. Introduction to Probability and Statistics for Engineers. 4 Units.
Probability: random variables, independence, and conditional probability; discrete and continuous distributions, moments, distributions of several random variables. Topics in mathematical statistics: random sampling, point estimation, confidence intervals, hypothesis testing, non-parametric tests, regression and correlation analyses; applications in engineering, industrial manufacturing, medicine, biology, and other fields. Prerequisite: CME 100/ENGR154 or MATH 51 or 52.
Same as: CME 106

ENGR 159Q. Japanese Companies and Japanese Society. 3 Units.
Preference to sophomores. The structure of a Japanese company from the point of view of Japanese society. Visiting researchers from Japanese companies give presentations on their research enterprise. The Japanese research ethic. The home campus equivalent of a Kyoto SCTI course.
Same as: MATSCI 159Q

ENGR 192. Engineering Public Service Project. 1-2 Unit.
Volunteer work on a public service project with a technical engineering component. Project requires a faculty sponsor and a community partner such as a nonprofit organization, school, or individual. Required report. See http://soe.stanford.edu/publicservice. May be repeated for credit. Prerequisite: consent of instructor.

ENGR 199. Special Studies in Engineering. 1-15 Unit.
Special studies, lab work, or reading under the direction of a faculty member. Often research experience opportunities exist in ongoing research projects. Students make arrangements with individual faculty and enroll in the section number corresponding to the particular faculty member. May be repeated for credit. Prerequisite: consent of instructor.

ENGR 199W. Writing of Original Research for Engineers. 1-3 Unit.
Technical writing in science and engineering. Students produce a substantial document describing their research, methods, and results. Prerequisite: completion of freshman writing requirements; prior or concurrent in 2 units of research in the major department; and consent of instructor. WIM for BioMedical Computation.

ENGR 202S. Writing: Special Projects. 1 Unit.
Writing tutorial for students working on non-course projects such as theses, journal articles, and conference papers. Weekly individual conferences.

ENGR 202W. Technical Writing. 3 Units.
How to write clear, concise, and well-ordered technical prose. Principles of editing for structure and style. Applications to a variety of genres in engineering and science.

ENGR 205. Introduction to Control Design Techniques. 3 Units.
Review of root-locus and frequency response techniques for control system analysis and synthesis. State-space techniques for modeling, full-state feedback regulator design, pole placement, and observer design. Combined observer and regulator design. Lab experiments on computers connected to mechanical systems. Prerequisites: 105, MATH 103, 113. Recommended: Matlab.

ENGR 206. Control System Design. 3-4 Units.
Design and construction of a control system and working plant. Topics include: linearity, actuator saturation, sensor placement, controller and model order; linearization by differential actuation and sensing; analog op-amp circuit implementation. Emphasis is on qualitative aspects of analysis and synthesis, generation of candidate design, and engineering tradeoffs in system selection. Large team-based project. Limited enrollment. Prerequisite: 105.

ENGR 207A. Linear Control Systems I. 3 Units.
Introduction to control of discrete-time linear systems. State-space models. Controllability and observability. The linear quadratic regulator. Prerequisite: 105 or 205.

ENGR 207B. Linear Control Systems II. 3 Units.
Probabilistic methods for control and estimation. Statistical inference for discrete and continuous random variables. Linear estimation with Gaussian noise. The Kalman filter. Prerequisite: EE 263.

ENGR 209A. Analysis and Control of Nonlinear Systems. 3 Units.
Introduction to nonlinear phenomena: multiple equilibria, limit cycles, bifurcations, complex dynamical behavior. Planar dynamical systems, analysis using phase plane techniques. Describing functions. Lyapunov stability theory. SISO feedback linearization, sliding mode control. Design examples. Prerequisite: 205.

ENGR 210. Perspectives in Assistive Technology (ENGR 110). 1-3 Unit.
Seminar and student project course. Explores the medical, social, ethical, and technical challenges surrounding the design, development, and use of technologies that improve the lives of people with disabilities and older adults. Guest lecturers include engineers, clinicians, and individuals with disabilities. Tours of local facilities, assistive technology faire, and movie screening. Juniors, seniors, and graduate students from any discipline welcome. Enrollment limited to class capacity of 45. 1 unit for seminar attendance only (CR/NC) or individual project (letter grade). 3 units for students who pursue a team-based assistive technology project. Projects can be continued as independent study in Spring Quarter. See http://engr110.stanford.edu/. Service Learning Course (certified by Haas Center for Public Service).
Same as: ENGR 110

ENGR 213. Solar Decathlon. 1-4 Unit.
Open to all engineering majors. Project studio for all work related to the Solar Decathlon 2013 competition. Each student will develop a personal work plan for the quarter with his or her advisor and perform multidisciplinary collaboration on designing systems for the home or pre-construction planning. Work may continue through the summer as a paid internship, as well as through the next academic year. For more information about the team and the competition, please visit solardecathlon.stanford.edu.

ENGR 213A. Solar Decathlon 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 113A

ENGR 213B. Solar Decathlon 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 113B

ENGR 213C. Solar Decathlon 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 113C

ENGR 213D. SOLAR DECATHLON 2015. 3 Units.
Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (http://www.solardecathlon.gov/) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.
Same as: ENGR 113D

ENGR 215. Design the Tech Challenge. 2 Units.
Students work with Tech Museum of San Jose staff to design the Tech Challenge, a yearly engineering competition for 6-12th grade students. Brainstorming, field trips to the museum, prototyping, coaching, and presentations to the Tech Challenge advisory board. See at http://techchallenge.thetech.org. May be repeated for credit.
Same as: ENGR 115

ENGR 231. Transformative Design. 3 Units.
Too many alums are doing what they've always been told they're good at, and are living with regret and a sense that they're just resigned to doing this thing for the rest of their lives. Capabilities displaced their values as the primary decision driver in their lives. Our ultimate goal is to restore a sense of agency and passion into the lives of current Stanford students by creating the space to explore and experiment with the greatest design project possible: YOUR LIFE. We will turn d.school tools and mindsets onto the topic of our lives -- not in theory, but in reality -- and will prototype changes to make life more fulfilling and rewarding. We will actively empathize and experiment in your life, so if you don't want to do that kind of self-examination, this class will not be a good fit for you.

ENGR 240. Introduction to Micro and Nano Electromechanical Systems. 3 Units.
Miniaturization technologies now have important roles in materials, mechanical, and biomedical engineering practice, in addition to being the foundation for information technology. This course will target an audience of first-year engineering graduate students and motivated senior-level undergraduates, with the goal of providing an introduction to M/NEMS fabrication techniques, selected device applications, and the design tradeoffs in developing systems. The course has no specific prerequisites, other than graduate or senior standing in engineering; otherwise, students will require permission of the instructors.

ENGR 245. The Lean LaunchPad: Getting Your Lean Startup Off the Ground. 3-4 Units.
Apply the "Lean Startup" principles; "business model canvas," "customer development" and "Agile Engineering" to prototype, test, and iterate your idea while discovering if you have a profitable business model. This is the class adopted by the NSF and NIH as the Innovation Corps. Apply and work in teams. Info sessions held in November and December. Team applications required in December. Proposals can be software, hardware, or service of any kind. Projects are experiential and require incrementally building the product while talking to customers/partners each week. Prerequisite: interest and passion in exploring whether a technology idea can become a real company. Limited enrollment.

ENGR 250. Data Challenge Lab. 1-6 Unit.
In this lab, students develop the practical skills of data science by solving a series of increasingly difficult, real problems. Skills developed include: data manipulation, exploratory data analysis, data visualization, and predictive modeling. The data challenges each student undertakes are based upon their current skills. Students receive one-on-one coaching and see how expert practitioners solve the same challenges. Limited enrollment; application required. May be repeated for credit. See http://datalab.stanford.edu for more information.

ENGR 280. From Play to Innovation. 2-4 Units.
Focus is on enhancing the innovation process with playfulness. The class will be project-based and team-centered. We will investigate the human "state of play" to reach an understanding of its principal attributes and how important it is to creative thinking. We will explore play behavior, its development, and its biological basis. We will then apply those principles through design thinking to promote innovation in the corporate world. Students will work with real-world partners on design projects with widespread application. This course requires an application. You can find the application here: dschool.stanford.edu/classes.

ENGR 281. d.media 4.0 - Designing Media that Matters. 2-3 Units.
Design practicum; project-based. Explore the why & how of designing media. What motivates our consumption of media, what real needs linger beneath the surface? How do you design a new media experience? Join us and find out. The world is Changing, What Are You Going to Do About It? In the shift from a consumer culture to a creative society has old media institutions collapsing while participatory media frameworks are emerging. Media designers of all types have an opportunity and responsibility to make this change positive. 3 Projects explore: Communication Design, Digital Interaction, User Motivations. Admission by application. See dschool.stanford.edu/classes for more information.

ENGR 290. Graduate Environment of Support. 1 Unit.
For course assistants (CAs) and tutors in the School of Engineering tutorial and learning program. Interactive training for effective academic assistance. Pedagogy, developing course material, tutoring, and advising. Sources include video, readings, projects, and role playing.

ENGR 298. Seminar in Fluid Mechanics. 1 Unit.
Interdepartmental. Problems in all branches of fluid mechanics, with talks by visitors, faculty, and students. Graduate students may register for 1 unit, without letter grade; a letter grade is given for talks. May be repeated for credit.

ENGR 299. Special Studies in Engineering. 1-15 Unit.
Special studies, lab work, or reading under the direction of a faculty member. Often research experience opportunities exist in ongoing research projects. Students make arrangements with individual faculty and enroll in the corresponding section. Prerequisite: consent of instructor.

ENGR 311A. Women's Perspectives. 1 Unit.
Master's and Ph.D. seminar series driven by student interests. Possible topics: time management, career choices, health and family, diversity, professional development, and personal values. Guest speakers from academia and industry, student presentations with an emphasis on group discussion. Graduate students share experiences and examine scientific research in these areas. May be repeated for credit.

ENGR 311B. Designing the Professional. 1 Unit.
How to Get a Life as well as a PhD: Seminar open to ALL doctoral students (Humanities, Sciences and Engineering). Apply principles of design thinking to designing your professional life following Stanford. Topics include: Introduction to "design thinking", a framework for vocational wayfinding and locating profession within life overall; tools to investigate multiple professional paths. Creation of personal "Odyssey Plan" to innovate multiple prototypes for post-PhD professional launch.

ENGR 311C. Expanding Engineering Limits: Culture, Diversity, and Gender. 1-2 Unit.
This course considers how culture shapes and impacts engineering, with a particular focus on the cultural aspects of gender that affect who becomes an engineer, what problems get solved, and the quality of solutions, design, technology, and products. We will examine engineering cultures and gender through the lens of iquest;design thinkingiquest;, which is an increasingly visible component of engineering education and practice. Design processes are determined by the designers, their disciplinary backgrounds, and the methods they use. How do the background characteristics of the designer affect products and development in innovation and research? Does gender matter? What about other characteristics of the designer? How can design thinking help to find sustainable solutions and also consider gender and diversity perspectives?.
Same as: FEMGEN 311C

ENGR 312. Science and Engineering Course Design. 2-3 Units.
For students interested in an academic career and who anticipate designing science or engineering courses at the undergraduate or graduate level. Goal is to apply research on science and engineering learning to the design of effective course materials. Topics include syllabus design, course content and format decisions, assessment planning and grading, and strategies for teaching improvement.
Same as: CTL 312

ENGR 313. Topics in Engineering and Science Education. 1-2 Unit.
This seminar series focuses on topics related to teaching science, technology, engineering, and math (STEM) courses based on education research. Each year focuses on a different topic related to STEM education. This course may be repeated for credit each year. This year we will explore how to design assessments and give feedback to facilitate student learning through a series of discussions, in-class activities and guest lectures based on current STEM education literature. Throughout the quarter, there will be several opportunities for directly practicing and applying STEM education strategies to specific teaching goals in your field.

ENGR 341. Micro/Nano Systems Design and Fabrication. 3-5 Units.
Laboratory course in micro and nano fabrication technology that combines lectures on theory and fundamentals with hands-on training in the Stanford Nanofabrication Facility. Prerequisite: ENGR 240 or equivalent.

ENGR 342. MEMS Laboratory II. 3-4 Units.
Emphasis is on tools and methodologies for designing and fabricating N/MEMS-based solutions. Student interdisciplinary teams collaborate to invent, develop, and integrate N/MEMS solutions. Design alternatives fabricated and tested with emphasis on manufacturability, assembly, test, and design. Limited enrollment. Prerequisite: ENGR 341.

ENGR 350. Data Impact Lab. 1-6 Unit.
In this lab, multi-disciplinary teams of students tackle high-impact, unsolved problems for social sector partners. Teams receive mentorship and coaching from Stanford faculty, domain experts, and data science experts from industry. Sample projects include innovations for: poverty alleviation in the developing world, local government services, education, and healthcare. Limited enrollment; application required. May be repeated for credit. See http://datalab.stanford.edu for more information.