Courses offered by the School of Engineering are listed under the subject code ENGR on the Stanford Bulletin’s ExploreCourses web site.

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 expertise embrace both engineering and the supporting sciences, there are numerous interdisciplinary research centers and 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, Energy, and Environmental Sciences.

The School of Engineering’s Hasso Plattner Institute of Design (also known as “the d.school,” 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 (https://engineering.stanford.edu/students/global-engineering-programs) 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:

- 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: If in doubt about requirements, courses should always be taken for a letter grade.

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. All students admitted to Stanford as undergraduates can have pathways to success in any engineering major at Stanford.
Recommended Preparation

Freshman
Students who plan to enter Stanford as freshmen and intend to major in engineering are advised to take the highest level of mathematics offered in high school. (See the "AP Credit (http://exploredegrees.stanford.edu/undergraduatedegreesandprograms/#aptext)" 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. Alternately, these courses can be taken after arrival at Stanford, and the best advice would be to begin early and have a detailed plan for completing requirements worked out.

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 mentioned under the Majors tab. 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 six Engineering B.S. subplans that have been proposed by cognizant faculty groups and approved by the Undergraduate Council:

- 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:

- Aeronautics and Astronautics
- 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 (two-three courses minimum, depending up individual program requirements; 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 2017-18 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 (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
- Micro rheology
- 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
- Environmental Engineering
- 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
- Algorithms
- 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
- Computational Social Science
- Computer Architecture
- Computer Graphics
- Computer Security
- Computer Science Education
- Computer Sound
- Computer Vision
- Crowdsourcing
- Cryptography
- Database Systems
- Data Center Computing
- Data Mining
- Design and Analysis of Algorithms
- Distributed and Parallel Computation
- Distributed Systems
- Education and Learning Science
- 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, Sensors and Systems
- Biomedical Imaging
- Communications Systems
- Control and Optimization
- Data Science
- Data Science
- Electronic Devices
- Embedded Systems
- Energy Harvesting and Conversion
- Energy-Efficient Hardware Systems
- Information Theory and Applications
- Integrated Circuits and Power Electronics
- Integrated Circuits and Power Electronics
- Mobile Networking
- Nanotechnology and NEMS/MEMS
- Photonics, Nanoscience and Quantum Technology
- Secure Distributed Systems
- Signal Processing and Multimedia
- Societal Networks
- Software Defined Networking

Management Science and Engineering
- Decision and Risk Analysis
- Dynamic Systems
- Economics
- Entrepreneurship
- Finance
- Information
- Marketing
- Optimization
- Organization Behavior
- Organizational Science
- Policy
- Production
Departments within the School of Engineering offer programs leading to the Bachelor of Science degree in the following fields:

- Aeronautics and Astronautics
- 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 Bachelor of Science degree in Engineering with specializations in:

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

In addition, students may elect a Bachelor of Science 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 Aeronautics and Astronautics, Bioengineering, Chemical Engineering, Civil and Environmental Engineering, Computer Science, Electrical Engineering, Materials Science and Engineering, and Mechanical Engineering, as well as the faculty overseeing the Architectural Design, Atmosphere/Energy, Biomechanical Engineering, Biomedical Computation, 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, differential equations, an introduction to discrete mathematics, and an understanding of statistics and probability theory. Students are encouraged to select courses on these topics. Courses that satisfy the math requirement are listed at http://ughb.stanford.edu on the Approved Courses page of the Courses and Planning section.

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 on the Approved Courses page of the Courses and Planning section.

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 two to three courses from the following list (the number depends upon the individual requirements of each major program):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 10</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 14</td>
<td>Intro to Solid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 15</td>
<td>Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 20</td>
<td>Introduction to Chemical Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 21</td>
<td>Engineering of Systems</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 25B</td>
<td>Biotechnology</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 25E</td>
<td>Energy: Chemical Transformations for Production, Storage, and Use (same as CHEMENG 25E)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 40</td>
<td>Introductory Electronics</td>
<td>1,2</td>
</tr>
<tr>
<td>ENGR 40A</td>
<td>Introductory Electronics</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 40M</td>
<td>An Intro to Making: What is EE</td>
<td>1-3,5</td>
</tr>
<tr>
<td>ENGR 50</td>
<td>Introduction to Materials Science, Nanotechnology Emphasis</td>
<td>1-2</td>
</tr>
<tr>
<td>ENGR 50E</td>
<td>Introduction to Materials Science, Energy Emphasis</td>
<td>1-2</td>
</tr>
<tr>
<td>ENGR 50M</td>
<td>Introduction to Materials Science, Biomanufacturing Emphasis</td>
<td>1-2</td>
</tr>
<tr>
<td>ENGR 60</td>
<td>Engineering Economics and Sustainability</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 62</td>
<td>Introduction to Optimization (same as MS&amp;E 111)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 70A/CS 106A</td>
<td>Programming Methodology</td>
<td>5</td>
</tr>
<tr>
<td>ENGR 70B/CS 106B</td>
<td>Programming Abstractions</td>
<td>5</td>
</tr>
<tr>
<td>ENGR 70X/CS 106X</td>
<td>Programming Abstractions (Accelerated)</td>
<td>5</td>
</tr>
<tr>
<td>ENGR 80</td>
<td>Introduction to Bioengineering (Engineering Living Matter) (same as BIOE 80)</td>
<td>4</td>
</tr>
</tbody>
</table>

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 on the Approved Courses page of the Courses and Planning section.

Basic Requirement 5 (Engineering Topics)
In order to satisfy ABET (Accreditation Board for Engineering and Technology) requirements, a student majoring in Civil or Mechanical Engineering must complete one and a half years of engineering topics, consisting of a minimum of 6 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 on the individual major page as listed in the Degree Programs section.

Experimentation
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, autonomous systems, computational engineering, embedded programming, fluids engineering, and heat transfer. The major prepares students for careers in aircraft and spacecraft engineering, autonomy, robotics, unmanned aerial vehicles, drones, space exploration, air and space-based telecommunication industries, computational engineering,
teaching, research, military service, and other related technology-intensive fields.

Completion of the undergraduate program in Aeronautics and Astronautics leads to the conferral of the Bachelor of Science in Aeronautics and Astronautics.

**Requirements**

**Mathematics**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 19 Calculus (required)</td>
<td>4</td>
</tr>
<tr>
<td>MATH 20 Calculus (required)</td>
<td>4</td>
</tr>
<tr>
<td>MATH 21 Calculus (required)</td>
<td>5</td>
</tr>
<tr>
<td>CME 100/ENGR 154 Vector Calculus for Engineers (required)</td>
<td>5</td>
</tr>
<tr>
<td>or MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications</td>
<td>5</td>
</tr>
<tr>
<td>CME 102/ENGR 155A Ordinary Differential Equations for Engineers (required)</td>
<td>5</td>
</tr>
<tr>
<td>or MATH 53 Ordinary Differential Equations with Linear Algebra</td>
<td>5</td>
</tr>
<tr>
<td>CME 106/ENGR 155C Introduction to Probability and Statistics for Engineers (required)</td>
<td>4-5</td>
</tr>
<tr>
<td>or STATS 110 Statistical Methods in Engineering and the Physical Sciences</td>
<td>4-5</td>
</tr>
<tr>
<td>or STATS 116 Theory of Probability</td>
<td>4-5</td>
</tr>
<tr>
<td>or CS 109 Introduction to Probability for Computer Scientists</td>
<td>4-5</td>
</tr>
<tr>
<td>CME 104 Linear Algebra and Partial Differential Equations for Engineers (recommended)</td>
<td>5</td>
</tr>
<tr>
<td>or MATH 52 Integral Calculus of Several Variables</td>
<td>5</td>
</tr>
<tr>
<td>CME 108 Introduction to Scientific Computing (recommended)</td>
<td>5</td>
</tr>
</tbody>
</table>

**Science**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 41 Mechanics (required)</td>
<td>4</td>
</tr>
<tr>
<td>or PHYSICS 41B Mechanics, Concepts, Calculations, and Context</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 43 Electricity and Magnetism (required)</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 45 Light and Heat (required)</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 31X Chemical Principles Accelerated (or CHEM 31A and CHEM 31B, or AP Chemistry) (required)</td>
<td>5</td>
</tr>
<tr>
<td>ENGR 80 Introduction to Bioengineering (Engineering Living Matter) (recommended)</td>
<td>5</td>
</tr>
<tr>
<td>or PHYSICS 41 Mechanics, Concepts, Calculations, and Context, or AP Physics B (recommended)</td>
<td>5</td>
</tr>
</tbody>
</table>

School of Engineering approved Science Electives: See Undergraduate Handbook, Figure 4-2

**Technology in Society (one course required)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 131 Ethical Issues in Engineering (recommended)</td>
<td>4</td>
</tr>
<tr>
<td>AA 252 Techniques of Failure Analysis (recommended)</td>
<td>3</td>
</tr>
</tbody>
</table>

**Engineering Fundamentals (three courses required)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 21 Engineering of Systems (required)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 70A/CS 106A Programming Methodology (required)</td>
<td>5</td>
</tr>
<tr>
<td>ENGR 10 Introduction to Engineering Analysis (recommended)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 40M An Intro to Making: What is EE (recommended)</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Fundamentals Elective; see list of Approved Courses in Undergraduate Engineering Handbook website at ughb.stanford.edu, Figure 4-4

**Aero/Astro Depth Requirements**

27 units minimum

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 14 Intro to Solid Mechanics (required)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 15 Dynamics (required)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 105 Feedback Control Design (required)</td>
<td>3</td>
</tr>
<tr>
<td>ME 30 Engineering Thermodynamics (required)</td>
<td>3</td>
</tr>
<tr>
<td>AA 100 Introduction to Aeronautics and Astronautics (required)</td>
<td>3</td>
</tr>
<tr>
<td>AA 101 Introduction to Aero Fluid Mechanics, required</td>
<td>1</td>
</tr>
<tr>
<td>AA 102 Introduction to Applied Aerodynamics</td>
<td>3</td>
</tr>
<tr>
<td>AA 103 Air and Space Propulsion</td>
<td>3</td>
</tr>
<tr>
<td>AA 131 Space Flight (required)</td>
<td>3</td>
</tr>
<tr>
<td>AA 141 Atmospheric Flight (required)</td>
<td>3</td>
</tr>
<tr>
<td>AA 171 Autonomous Systems, required</td>
<td>1</td>
</tr>
<tr>
<td>AA 190 Directed Research and Writing in Aero/Astro</td>
<td>3-5</td>
</tr>
</tbody>
</table>

**Aero/Astro Focus Electives**

15 units minimum

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 111 Introduction to Aerospace Computational Engineering</td>
<td>1</td>
</tr>
<tr>
<td>AA 135 Introduction to Space Policy</td>
<td>1</td>
</tr>
<tr>
<td>AA 151 Lightweight Structures</td>
<td>3</td>
</tr>
<tr>
<td>AA 156 Mechanics of Composite Materials</td>
<td>3</td>
</tr>
<tr>
<td>AA 173 Flight Mechanics and Controls</td>
<td>1</td>
</tr>
<tr>
<td>AA 175 Embedded Programming</td>
<td>1</td>
</tr>
<tr>
<td>AA 272C Global Positioning Systems</td>
<td>3</td>
</tr>
<tr>
<td>AA 279A Space Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>AA 199 Independent Study in Aero/Astro</td>
<td>1-5</td>
</tr>
<tr>
<td>MS&amp;E 178 The Spirit of Entrepreneurship</td>
<td>2</td>
</tr>
</tbody>
</table>

**Aero/Astro Suggested Courses (not required)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 149 Operation of Aerospace Systems</td>
<td>1</td>
</tr>
</tbody>
</table>

**Aero/Astro Capstone Requirement**

7 units minimum

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 123A Air Capstone I, satisfies the Writing in the Major requirement, (WIM)</td>
<td>1</td>
</tr>
<tr>
<td>AA 123B Air Capstone II</td>
<td>1</td>
</tr>
<tr>
<td>AA 124A Space Capstone I, satisfies the Writing in Major requirement, (WIM)</td>
<td>1</td>
</tr>
<tr>
<td>AA 124B Space Capstone II</td>
<td>1</td>
</tr>
</tbody>
</table>

For additional information and sample programs see the Handbook for Undergraduate Engineering (http://ughb.stanford.edu) and the Aeronautics and Astronautics Undergraduate Program Sheet (https://ughb.stanford.edu/program-sheets).

All courses taken for the major must be taken for a letter grade if that option is offered by the instructor.

Minimum Combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.

Transfer and AP credits in Math, Science, Fundamentals, and the Technology in Society course must be approved by the School of Engineering Dean’s office.
This course will be offered in the near future. See the department’s web site for more information about our future course offerings (https://aa.stanford.edu/academics/undergraduate-program). For courses yet not offered please contact the Aero/Astro Student Services Office (https://aa.stanford.edu/academics/student-services-office) for a list of approved replacement courses.

A score of 4 on the Calculus BC test or 5 on the AB test only gives students 8 units, not 10 units, so is equal to MATH 19 + MATH 20, but not MATH 21. The Math Placement Exam determines what math course the student starts with.

It is recommended that the CME series (100, 102, 104) be taken rather than the MATH series (51, 52, 53). It is recommended that students taking the MATH series also take CME 192 Introduction to MATLAB.

A score of 4 or 5 on the AP Physics C Mechanics test places the student out of PHYSICS 41. Similarly, a 4 or 5 on the AP Physics Electricity and Magnetism test places the student out of PHYSICS 43.

Honors Program

The Department of Aeronautics and Astronautics plans to offer an honors program designed to allow undergraduates with strong records and enthusiasm for independent research to engage in a significant project leading to a degree with departmental honors. This honors program requires approval by University governance and the Western Association of Schools and Colleges (WASC).

Students who meet the eligibility criteria and wish to be considered for the honors program should apply to the program by the end of the junior year. All applications are subject to the review and final approval by the Aero/Astro Undergraduate Curriculum Committee.

Application Requirements:

- One-page written statement describing the research topic and signed adviser form
- GPA of 3.5 or higher in the major
- Unofficial Stanford transcript (from Axess)
- Signature of thesis adviser

Honors criteria:

- Maintain the 3.5 GPA required for admissions to the honors program.
- Arrangement with an Aero/Astro faculty member who agrees to serve as the thesis adviser. The adviser must be a member of the Academic Council.
- Under the direction of the thesis adviser, complete at least two quarters of research with a minimum of 9 units of independent research; 3 of these units may be used towards a student’s Aero/Astro Focus Elective requirement.
- Submit an honors thesis (20-30 pages).
- Attend Research Experience for Undergraduates Poster Session or present in another suitable forum approved by the faculty adviser.

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

<table>
<thead>
<tr>
<th>Mathematics and Science (36 units minimum)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td></td>
</tr>
<tr>
<td>MATH 19 Calculus</td>
<td>3</td>
</tr>
<tr>
<td>MATH 20 Calculus</td>
<td>3</td>
</tr>
<tr>
<td>MATH 21 Calculus</td>
<td>4</td>
</tr>
<tr>
<td>Or 10 units AP Calculus or MATH 41 &amp; MATH 42</td>
<td></td>
</tr>
<tr>
<td>CME 100 Vector Calculus for Engineers (Recommended)</td>
<td>5</td>
</tr>
<tr>
<td>One course in Statistics (required)</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Science

| PHYSICS 41 Mechanics (or PHYSICS 41E (requires Physics diagnostic test or application)) | 4/5   |

Recommended:

| EARTHSYS 101 Energy and the Environment                      |       |
| EARTHSYS 102 Fundamentals of Renewable Power               |       |
| CEE 64 Air Pollution and Global Warming: History, Science, and Solutions |       |
| CEE 70 Environmental Science and Technology                |       |
| PHYSICS 23 Electricity, Magnetism, and Optics               |       |
| CME 24 Fundamentals of Renewable Power                      |       |

Or from School of Engineering approved list

Technology in Society

One course required; course chosen must be on the SoE Approved Courses list at <ughb.stanford.edu> the year taken. 3-5

Engineering Fundamentals

Two courses minimum, see Basic Requirement 3 6-8

ENGR 14 Intro to Solid Mechanics 3

AD Depth Core 2

| CEE 31 Accessing Architecture Through Drawing or CEE 31Q Accessing Architecture Through Drawing | 5     |
| CEE 100 Managing Sustainable Building Projects (or CEE 32B or CEE 32D) | 4     |
| CEE 120A Building Information Modeling Workshop            | 2-4   |
| CEE 130 Architectural Design: 3-D Modeling, Methodology, and Process |       |
| CEE 137B Advanced Architecture Studio                       | 6     |
| ARTHIST 3 Introduction to World Architecture               | 5     |

Depth Options 12

See Note 2 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 131C How Buildings are Made – Materiality and Construction Methods | 4     |
| CEE 131D Urban Design Studio                                      | 5     |
| CEE 32D Construction: The Writing of Architecture                 |       |
| CEE 32G Architecture Since 1900                                   |       |
| CEE 32H Responsive Structures                                     |       |
| CEE 32V Architectural Design Lecture Series Course                |       |
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

Mathematics and Science (45 units minimum):

Mathematics

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
</tr>
<tr>
<td>23 units minimum, including at least one course from each group:</td>
</tr>
<tr>
<td>Group A</td>
</tr>
<tr>
<td>MATH 53</td>
</tr>
<tr>
<td>CME 102</td>
</tr>
<tr>
<td>Group B</td>
</tr>
<tr>
<td>CME 106</td>
</tr>
<tr>
<td>STATS 60</td>
</tr>
<tr>
<td>STATS 101</td>
</tr>
<tr>
<td>STATS 110</td>
</tr>
</tbody>
</table>

Science

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
</tr>
<tr>
<td>20 units minimum, including all of the following:</td>
</tr>
<tr>
<td>PHYSICS 41</td>
</tr>
<tr>
<td>or PHYSICS 49</td>
</tr>
<tr>
<td>PHYSICS 43</td>
</tr>
<tr>
<td>or PHYSICS 45</td>
</tr>
<tr>
<td>CHEM 31B</td>
</tr>
<tr>
<td>or CHEM 31D</td>
</tr>
<tr>
<td>CEE 70</td>
</tr>
</tbody>
</table>

Technology in Society (1 course) 3-5

One 3-5 unit course required; must be on School of Engineering Approved List the year taken.

Writing in the Major (WIM)

One 3-5 unit course required. Choose a TiS course that fulfills a WIM:

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>BIOE 131</td>
</tr>
<tr>
<td>COMM 120W</td>
</tr>
<tr>
<td>OR one of these WIM courses (do not fulfill TiS):</td>
</tr>
<tr>
<td>CEE 100</td>
</tr>
</tbody>
</table>
### School of Engineering

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARTHSYS 200</td>
<td>Environmental Communication in Action: The SAGE Project</td>
</tr>
<tr>
<td>ENGR 25E</td>
<td>Energy: Chemical Transformations for Production, Storage, and Use</td>
</tr>
<tr>
<td>ENGR 50E</td>
<td>Introduction to Materials Science, Energy Emphasis</td>
</tr>
<tr>
<td>ENGR 10</td>
<td>Introduction to Engineering Analysis</td>
</tr>
<tr>
<td>ENGR 70A</td>
<td>Programming Methodology</td>
</tr>
<tr>
<td>ENGR 202S</td>
<td>Directed Writing Projects</td>
</tr>
<tr>
<td>CEE 64</td>
<td>Air Pollution and Global Warming: History, Science, and Solutions (cannot also fulfill science requirement)</td>
</tr>
<tr>
<td>CEE 107A</td>
<td>Understanding Energy</td>
</tr>
<tr>
<td>CEE 107S</td>
<td>Understanding Energy - Essentials</td>
</tr>
<tr>
<td>CEE 161I</td>
<td>Natural Ventilation of Buildings</td>
</tr>
<tr>
<td>CEE 161I</td>
<td>Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation</td>
</tr>
<tr>
<td>CEE 162I</td>
<td>Atmosphere, Ocean, and Climate Dynamics: The Ocean Circulation</td>
</tr>
<tr>
<td>CEE 172</td>
<td>Air Quality Management</td>
</tr>
<tr>
<td>CEE 178</td>
<td>Introduction to Human Exposure Analysis</td>
</tr>
<tr>
<td>EARTHSYS 111</td>
<td>Biology and Global Change</td>
</tr>
<tr>
<td>EARTHSYS 142</td>
<td>Remote Sensing of Land</td>
</tr>
<tr>
<td>EARTHSYS 188</td>
<td>Social and Environmental Tradeoffs in Climate Decision-Making</td>
</tr>
<tr>
<td>ME 131B</td>
<td>Fluid Mechanics: Compressible Flow and Turbomachinery</td>
</tr>
<tr>
<td>PHYSICS 199</td>
<td>The Physics of Energy and Climate Change</td>
</tr>
<tr>
<td>EARTH 2</td>
<td>Climate and Society</td>
</tr>
<tr>
<td>EARTHSYS 196</td>
<td>Implementing Climate Solutions at Scale</td>
</tr>
<tr>
<td>CEE 156</td>
<td>Building Systems</td>
</tr>
<tr>
<td>CEE 173S</td>
<td>Electricity Economics</td>
</tr>
<tr>
<td>CEE 176A</td>
<td>Energy Efficient Buildings</td>
</tr>
<tr>
<td>CEE 176B</td>
<td>100% Clean, Renewable Energy and Storage for Everything</td>
</tr>
<tr>
<td>CEE 177S</td>
<td>Design for a Sustainable World</td>
</tr>
<tr>
<td>EARTHSYS 101</td>
<td>Energy and the Environment</td>
</tr>
<tr>
<td>EARTHSYS 102</td>
<td>Fundamentals of Renewable Power</td>
</tr>
<tr>
<td>ENERGY 104</td>
<td>Sustainable Energy for 9 Billion</td>
</tr>
<tr>
<td>ENGR 50E</td>
<td>Introduction to Materials Science, Energy Emphasis</td>
</tr>
<tr>
<td>MATSCI 144</td>
<td>Thermodynamic Evaluation of Green Energy Technologies</td>
</tr>
<tr>
<td>MATSCI 156</td>
<td>Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution</td>
</tr>
<tr>
<td>ME 182</td>
<td>Electric Transportation</td>
</tr>
<tr>
<td>POLISCI 73</td>
<td>Energy Policy in California and the West</td>
</tr>
<tr>
<td>OSPSANTG 29</td>
<td>Sustainable Cities: Comparative Transportation Systems in Latin America</td>
</tr>
<tr>
<td>OSPSANTG 52</td>
<td>Energy and Climate Cooperation in the Americas: The Role of Chile</td>
</tr>
</tbody>
</table>

| Total Units | 95-101 |

1. Can count as a science requirement or Engineering Fundamental, but not both.
2. CEE 64 can count as a science requirement or as Engineering Depth, but not both.
3. ENGR 50E can count as Engineering Fundamental or Engineering Depth, but not both.
4. A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Fundamentals and Depth is 2.0.
5. Courses outside of the School of Engineering (SoE) do not count toward the 40 units of engineering coursework required in the Fundamentals plus Depth categories.

### 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 student must adhere to the following requirements:

1. Prospective honors students write up and submit a 1-2 page letter applying to the honors program in A/E describing the problem to be investigated. The letter must be signed by the student, the current primary adviser, and the proposed honors adviser, if different, and submitted to the student services office in the Department of Civil and Environmental Engineering (CEE).
2. Prospective honors students write up and submit a 1-2 page letter applying to the honors program in A/E describing the problem to be investigated. The letter must be signed by the student, the current primary adviser, and the proposed honors adviser, if different, and submitted to the student services office in the Department of Civil and Environmental Engineering (CEE).
3. Prospective honors students meet with the proposed honors adviser well in advance of submitting an application.
4. Prospective honors students meet with the proposed honors adviser well in advance of submitting an application.
5. Prospective honors students meet with the proposed honors adviser well in advance of submitting an application.
6. Prospective honors students meet with the proposed honors adviser well in advance of submitting an application.
7. Prospective honors students meet with the proposed honors adviser well in advance of submitting an application.
7. Two copies of the signed thesis must be provided to the CEE student services office no later than two weeks before the end of the student’s 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 conferment of the Bachelor of Science in Bioengineering.

**Mission of the Undergraduate Program in Bioengineering**

The Stanford Bioengineering 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 bioengineering 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) (http://bioengineering.stanford.edu/student-resources/reu) program. BIOE graduates are well prepared to pursue careers and lead projects in research, medicine, business, law, and policy.

**Requirements**

**Mathematics**

14 units minimum (Prerequisites: 10 units of AP or IB credit or Mathematics 20-series)  
1. Select one of the following sequences:

| CME 100 & CME 102 | Vector Calculus for Engineers and Ordinary Differential Equations for Engineers (Recommended) | 10 |
| MATH 51 & MATH 53 | Linear Algebra, Multivariable Calculus, and Modern Applications and Ordinary Differential Equations with Linear Algebra | 10 |

2. Select one of the following:

| CME 106 or STATS 110 | Introduction to Probability and Statistics for Engineers (Recommended) | 4-5 |
| STATS 141 | Biostatistics | |

**Science**

26 units minimum  
2. Select one of the following:

| CHEM 31X or CHEM 31A & CHEM 31B | Chemical Principles Accelerated and Chemical Principles I and Chemical Principles II | 5-10 |
| CHEM 33 | Structure and Reactivity of Organic Molecules | 5 |
| BIO 83 or BIO 82 | Biochemistry & Molecular Biology (Recommended) and Genetics | 4 |
| BIO 84 | Physiology | 4 |
| PHYSICS 41 | Mechanics | 4 |
| PHYSICS 43 | Electricity and Magnetism | 4 |

**Technology in Society**

| BIOE 131 | Ethics in Bioengineering (WIM) | 3 |

**Engineering Fundamentals**

| BIOE 80 | Introduction to Bioengineering (Engineering Living Matter) | 4 |
| CS 106A | Programming Methodology (or CS 106B or CS 106X) | 5 |

Fundamentals Elective; see UGHB for approved course list; only one CS class allowed to count toward Fundamentals requirements.

**Bioengineering Core**

| BIOE 42 | Physical Biology | 4 |
| BIOE 44 | Fundamentals for Engineering Biology Lab | 4 |
| BIOE 101 | Systems Biology | 3 |
| BIOE 103 | Systems Physiology and Design | 4 |
| BIOE 123 | Biomedical System Prototyping Lab | 4 |
| BIOE 141A | Senior Capstone Design I | 4 |
| BIOE 141B | Senior Capstone Design II | 4 |

**Bioengineering Depth Electives**

Four courses, minimum 12 units:

| BIOE 115 | Computational Modeling of Microbial Communities |
| BIOE 122 | Biosecurity and Bioterrorism Response |
| BIOE 140 | Introduction to Bioinformatics |
| 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 217 | Translational Bioinformatics |
| BIOE 220 | Introduction to Imaging and Image-based Human Anatomy or BIOE 51 | |
| BIOE 221 | Anatomy for Bioengineers |
| BIOE 222 | Physics and Engineering of Radionuclide-based Medical Imaging |
| BIOE 223 | Instrumentation and Applications for Multi-modality Molecular Imaging of Living Subjects |
| BIOE 224 | Physics and Engineering of X-Ray Computed Tomography |
| BIOE 225 | 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 260 | Tissue Engineering |
| BIOE 279 | Computer Graphics: Structure and Organization of Biomolecules and Cells |
| BIOE 281 | Biomechanics of Movement |
| BIOE 291 | Principles and Practice of Optogenetics for Optical Control of Biological Tissues |

1. It is strongly recommended that CME 100 Vector Calculus for Engineers and CME 102 Ordinary Differential Equations for Engineers be taken rather than MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications and MATH 53 Ordinary Differential Equations with Linear Algebra. If you are taking the MATH 50 series, it is strongly recommended to take CME 192 Introduction to MATLAB. 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. Although not required, CME 104 Linear Algebra and Partial Differential Equations for Engineers is recommended for some Bioengineering courses.
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 (PHYSICS 41 Mechanics and PHYSICS 43 Electricity and Magnetism), 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.

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

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 third week of Spring Quarter and give a poster or oral presentation, or present in another approved suitable forum.
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 Bioengineering Honors Program (http://bioengineering.stanford.edu/academics/undergraduate-programs/bioengineering-honors-program) web site.

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, biomechanics, medicine or related areas.

Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics</strong></td>
<td></td>
</tr>
<tr>
<td>21 units minimum; CME sequence is recommended, but MATH sequence is acceptable; see Basic Requirement 1</td>
<td>21</td>
</tr>
<tr>
<td>CME 102/ ENGR 155A, or MATH 53 Ordinary Differential Equations for Engineers</td>
<td></td>
</tr>
<tr>
<td><strong>Select one of the following:</strong></td>
<td></td>
</tr>
<tr>
<td>CME 106/ ENGR 155C, Introduction to Probability and Statistics for Engineers</td>
<td></td>
</tr>
<tr>
<td>STATS 110, Statistical Methods in Engineering and the Physical Sciences</td>
<td></td>
</tr>
<tr>
<td>STATS 116, Theory of Probability</td>
<td></td>
</tr>
<tr>
<td>STATS 141, Biostatistics</td>
<td></td>
</tr>
<tr>
<td><strong>Science (22 units Minimum)</strong></td>
<td></td>
</tr>
<tr>
<td>CHEM 31X, Chemical Principles Accelerated (or CHEM 31A+B)</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 33, Structure and Reactivity of Organic Molecules</td>
<td>5</td>
</tr>
<tr>
<td>PHYSICS 41, Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>or PHYSICS 411, Mechanics, Concepts, Calculations, and Context</td>
<td></td>
</tr>
<tr>
<td>Biology or Human Biology A/B core courses</td>
<td>8-10</td>
</tr>
<tr>
<td>BIO 45, Introduction to Laboratory Research in Cell and Molecular Biology (or BIO 44X if taken before 2016-17)</td>
<td>4</td>
</tr>
<tr>
<td>or BIOE 44, Fundamentals for Engineering Biology Lab</td>
<td></td>
</tr>
<tr>
<td><strong>Engineering Depth</strong></td>
<td></td>
</tr>
<tr>
<td>ENGR 15, Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 30, Engineering Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 70, Introductory Fluids Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ME 80, Mechanics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>ME 112, Mechanical Systems Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 389, Biomechanical Research Symposium</td>
<td>1</td>
</tr>
<tr>
<td><strong>Mechanical Engineering/ Biomechanical Engineering Depth</strong></td>
<td></td>
</tr>
<tr>
<td>Students are encouraged to carefully select ME and BME depth courses that complement each other and form a cohesive plan of study. Options to complete the ME depth sequence (3 courses, minimum 9 units) and WIM:</td>
<td>9</td>
</tr>
<tr>
<td>ENGR 105, Feedback Control Design</td>
<td></td>
</tr>
<tr>
<td>ME 102, Foundations of Product Realization</td>
<td></td>
</tr>
<tr>
<td>ME 131A, Heat Transfer</td>
<td></td>
</tr>
<tr>
<td>ME 131B, Fluid Mechanics: Compressible Flow and Turbomachinery</td>
<td></td>
</tr>
</tbody>
</table>

For 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 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.
- Submit an application to the ME student services office no later than the second week of the term two quarters before anticipated conferral (e.g., Autumn for Spring conferral, Spring for Autumn conferral). An application consists of:
  - A one page written statement describing the research topic, with signatures indicating approval of both the thesis adviser and thesis reader on a cover page
  - An unofficial Stanford transcript;
- 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.
- 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 by the 3rd week of the quarter they intend to confer. Further revisions and final endorsement by the adviser and reader are to be finished by week 6, when two bound copies are to be submitted to the Mechanical Engineering student services office.
  - Present the thesis at the Mechanical Engineering Poster Session held in mid-April. If the poster session is not offered or the student does not confer in the Spring, an alternative presentation will be approved on a case by case basis with advisor and BME Program Director approval.

Note: Students may not use work completed towards an honors degree to satisfy BME course requirements

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**

Quantitative and computational methods are central to the advancement of biology and medicine in the 21st century. 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 acquiring foundational knowledge in the underlying biological and computational disciplines. They learn techniques in informatics and simulation and their numerous 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 in a depth area of their choosing, and participate in a substantial research project with a Stanford faculty member. Upon graduation, students are prepared to enter a range of disciplines in either academia or industry.

**Requirements**

- **Mathematics**
  - 21 unit minimum, see Basic Requirement 1
  - MATH 19  Calculus (or AP Calculus )  3
  - MATH 20  Calculus (or AP Calculus)  3
Science
17 units minimum, see Basic Requirement 2

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 41</td>
<td>Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>or PHYSICS 411</td>
<td>Mechanics, Concepts, Calculations, and Context</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 31X</td>
<td>Chemical Principles Accelerated</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
<td>5</td>
</tr>
<tr>
<td>BIO 82</td>
<td>Genetics (or HUMBIO 2A)</td>
<td>4</td>
</tr>
<tr>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology (or BIO 84 or HUMBIO 3A)</td>
<td>4</td>
</tr>
<tr>
<td>BIO 86</td>
<td>Cell Biology (or HUMBIO 4A)</td>
<td>4</td>
</tr>
</tbody>
</table>

Engineering Fundamentals

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 106B</td>
<td>Programming Abstractions</td>
<td>3-5</td>
</tr>
<tr>
<td>or CS 106X</td>
<td>Programming Abstractions (Accelerated)</td>
<td>3-5</td>
</tr>
</tbody>
</table>

For the second required course, see concentrations 4

Technology in Society

One course required, see Basic Requirement 4; course used must be on the School of Engineering Approved Courses list in the UGHB the year taken.

Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 161</td>
<td>Design and Analysis of Algorithms</td>
<td>3-5</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 270</td>
<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
<td></td>
</tr>
<tr>
<td>CS 273A</td>
<td>The Human Genome Source Code</td>
<td></td>
</tr>
<tr>
<td>CS 274</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
<td></td>
</tr>
<tr>
<td>CS 275</td>
<td>Translational Bioinformatics</td>
<td></td>
</tr>
<tr>
<td>CS 279</td>
<td>Computational Biology: Structure and Organization of Biomolecules and Cells</td>
<td></td>
</tr>
</tbody>
</table>

Research: 6 units of biomedical computation research in any department 2

Engineering Depth Concentration (select one of the following concentrations): 7

**Cellular/Molecular Concentration**

Mathematics: Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
<td></td>
</tr>
<tr>
<td>STATS 141</td>
<td>Biostatistics</td>
<td></td>
</tr>
<tr>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications</td>
<td></td>
</tr>
<tr>
<td>One additional Engineering Fundamental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIO 104</td>
<td>Advance Molecular Biology: Epigenetics and Proteostasis</td>
<td></td>
</tr>
<tr>
<td>CHEM 141</td>
<td>The Chemical Principles of Life I (or CHEM 171)</td>
<td>4</td>
</tr>
</tbody>
</table>

Cell/Mol Electives (two courses) 5,6

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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 141</td>
<td>Biostatistics</td>
<td></td>
</tr>
<tr>
<td>STATS 203</td>
<td>Introduction to Regression Models and Analysis of Variance</td>
<td></td>
</tr>
<tr>
<td>STATS 205</td>
<td>Introduction to Nonparametric Statistics</td>
<td></td>
</tr>
<tr>
<td>STATS 215</td>
<td>Statistical Models in Biology</td>
<td></td>
</tr>
</tbody>
</table>

One additional Engineering Fundamental 4

Informatics Core (three courses):

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 145</td>
<td>Data Management and Data Systems</td>
<td></td>
</tr>
<tr>
<td>or CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td></td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td></td>
</tr>
<tr>
<td>or CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
<td></td>
</tr>
<tr>
<td>or CS 229</td>
<td>Machine Learning</td>
<td></td>
</tr>
</tbody>
</table>

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):

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
<td></td>
</tr>
<tr>
<td>STATS 141</td>
<td>Biostatistics</td>
<td></td>
</tr>
<tr>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications</td>
<td></td>
</tr>
</tbody>
</table>

One additional Engineering Fundamental 4

Biology (two courses):

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 112</td>
<td>Human Physiology</td>
<td></td>
</tr>
<tr>
<td>CHEM 141</td>
<td>The Chemical Principles of Life I (or BIOE 220)</td>
<td></td>
</tr>
<tr>
<td>Two additional Organs Electives 5,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation Electives (two courses) 5,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informatics Electives (two courses) 5,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation, Informatics, or Organs Elective (one course) 5,6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Simulation Concentration**

Mathematics:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
<td></td>
</tr>
<tr>
<td>or MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications</td>
<td></td>
</tr>
</tbody>
</table>

ME 30            | Engineering Thermodynamics (Fulfills 2nd Engineering Fundamental)            | 3     |

Simulation Core:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 102</td>
<td>Ordinary Differential Equations for Engineers</td>
<td>5</td>
</tr>
<tr>
<td>or MATH 53</td>
<td>Ordinary Differential Equations with Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>ENGR 80</td>
<td>Introduction to Bioengineering (Engineering Living Matter)</td>
<td>4</td>
</tr>
<tr>
<td>BIOE 101</td>
<td>Systems Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 103</td>
<td>Systems Physiology and Design</td>
<td>4</td>
</tr>
<tr>
<td>Simulation Electives (two courses) 5,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation, Cellular, or Organs Elective (two courses) 5,6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Units 88-104

1 Acceptable substitutes for CS 109 are STATS 116 Theory of Probability, MS&E 120 Probabilistic Analysis, MS&E 220 Probabilistic Analysis, EE 178 Probabilistic Systems Analysis, and CME 106 Introduction to Probability and Statistics for Engineers.
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.
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

Completion of the undergraduate program in Chemical Engineering leads to the conferment 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*

<table>
<thead>
<tr>
<th>Mathematics 1</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following sequence or approved AP credit</td>
<td>10</td>
</tr>
<tr>
<td>MATH 19 Calculus</td>
<td></td>
</tr>
<tr>
<td>MATH 20 Calculus</td>
<td></td>
</tr>
<tr>
<td>MATH 21 Calculus</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>5-10</td>
</tr>
<tr>
<td>CME 100 Vector Calculus for Engineers</td>
<td></td>
</tr>
<tr>
<td>MATH 51 &amp; MATH 52 Linear Algebra, Multivariable Calculus, and Modern Applications and Integral Calculus of Several Variables</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>5</td>
</tr>
<tr>
<td>CME 102 Ordinary Differential Equations for Engineers</td>
<td></td>
</tr>
<tr>
<td>or MATH 53 Ordinary Differential Equations with Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>4-5</td>
</tr>
<tr>
<td>CME 104 Linear Algebra and Partial Differential Equations for Engineers</td>
<td></td>
</tr>
<tr>
<td>or CME 106 Introduction to Probability and Statistics for Engineers</td>
<td></td>
</tr>
</tbody>
</table>

| Science 1 | |
| CHEM 31X Chemical Principles Accelerated | 5 |
| CHEM 33 Structure and Reactivity of Organic Molecules | 5 |
| CHEM 35 Organic Chemistry of Bioactive Molecules | 5 |
| PHYSICS 41 Mechanics | 4 |
| or PHYSICS 41B Mechanics, Concepts, Calculations, and Context | |
| PHYSICS 43 Electricity and Magnetism | 4 |
| CHEM 131 Organic Polyfunctional Compounds | 3 |

Technology in Society

One course required, see Basic Requirement 4; course chosen must be on the SoE-Approved Courses list at <ughb.stanford.edu> the year taken.

Engineering Fundamentals

Three courses minimum; see Basic Requirement 3

| CHEMENG/ENGR Introduction to Chemical Engineering 20 | 4 |
| 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 |
for graduate studies in engineering. Students for careers in consulting, industry and government, as well as to creatively solve engineering problems, and communicate their engineering to conduct experiments, design structures and systems. The major learn to apply knowledge of mathematics, science, and civil engineering to conduct experiments, design structures and systems or construction or environmental and water studies. Students in professional program balances the fundamentals common to many methodologies necessary for civil engineering practice. This pre-

The mission 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.

Civil Engineering (CE)

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

Requirements

Mathematics and Science
45 units minimum; see Basic Requirements 1 and 2

Technology in Society
One course; course chosen must be on the SoE Approved Courses list at ughb.stanford.edu the year taken; see Basic Requirement 4

Engineering Fundamentals
Two courses required

ENGR 14 Intro to Solid Mechanics 3
ENGR 90/CEE 70 Environmental Science and Technology 3

Engineering Depth
Minimum of 68 Engineering Fundamentals plus Engineering Depth; see Basic Requirement 5

CEE 100 Managing Sustainable Building Projects 3
CEE 101A Mechanics of Materials 4
CEE 101B Mechanics of Fluids 4
CEE 101C Geotechnical Engineering 4
CEE 146S Engineering Economics and Sustainability 3

Specialty courses in either:
Environmental and Water Studies (see below)
Structures and Construction (see below)
Other School of Engineering Electives 3

Total Units 115-117

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 GEOLSCI 1 Introduction to Geology; 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 GEOLSCI 1 is offered for AY 2018-19 is Spring Quarter.

Civil Engineering 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)

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

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

Environmental and Water Studies Focus

ME 30 Engineering Thermodynamics 3
CEE 101D Computations in Civil and Environmental Engineering (or CEE 101S) 3
CEE 102 Legal Principles in Design, Construction, and Project Delivery (or CEE 175A (alt years) or CEE 171 (no longer offered)) 3
CEE 162E Rivers, Streams, and Canals 3
CEE 166A Watersheds and Wetlands 4
CEE 166B Floods and Droughts, Dams and Aqueducts 4

Total Units 115-117
### Structures and Construction Focus

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 172</td>
<td>Air Quality Management</td>
<td>3</td>
</tr>
<tr>
<td>CEE 177</td>
<td>Aquatic Chemistry and Biology</td>
<td>4</td>
</tr>
<tr>
<td>CEE 179A</td>
<td>Water Chemistry Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>CEE 179C</td>
<td>Environmental Engineering Design</td>
<td>5</td>
</tr>
<tr>
<td>(or CEE 169)</td>
<td>Capstone design experience course</td>
<td></td>
</tr>
</tbody>
</table>

Remaining specialty units from:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 63</td>
<td>Weather and Storms</td>
<td>2</td>
</tr>
<tr>
<td>CEE 64</td>
<td>Air Pollution and Global Warming: History, Science,</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>and Solutions</td>
<td></td>
</tr>
<tr>
<td>CEE 107A</td>
<td>Understanding Energy</td>
<td>3-5</td>
</tr>
<tr>
<td>CEE 155</td>
<td>Introduction to Sensing Networks for CEE</td>
<td>4</td>
</tr>
<tr>
<td>CEE 161C</td>
<td>Natural Ventilation of Buildings</td>
<td>3</td>
</tr>
<tr>
<td>CEE 161I</td>
<td>Atmosphere, Ocean, and Climate Dynamics: The</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Atmospheric Circulation</td>
<td></td>
</tr>
<tr>
<td>CEE 162D</td>
<td>Introduction to Physical Oceanography</td>
<td>4</td>
</tr>
<tr>
<td>CEE 162F</td>
<td>Coastal Processes</td>
<td>3</td>
</tr>
<tr>
<td>CEE 162I</td>
<td>Atmosphere, Ocean, and Climate Dynamics: the Ocean</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Circulation</td>
<td></td>
</tr>
<tr>
<td>CEE 165C</td>
<td>Water Resources Management</td>
<td>3</td>
</tr>
<tr>
<td>CEE 166D</td>
<td>Water Resources and Water Hazards Field Trips</td>
<td>2</td>
</tr>
<tr>
<td>CEE 174A</td>
<td>Providing Safe Water for the Developing and</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Developed World</td>
<td></td>
</tr>
<tr>
<td>CEE 174B</td>
<td>Wastewater Treatment: From Disposal to Resource</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Recovery</td>
<td></td>
</tr>
<tr>
<td>CEE 176A</td>
<td>Energy Efficient Buildings</td>
<td>3-4</td>
</tr>
<tr>
<td>CEE 176B</td>
<td>100% Clean, Renewable Energy and Storage for</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Everything</td>
<td></td>
</tr>
<tr>
<td>CEE 178</td>
<td>Introduction to Human Exposure Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CEE 199</td>
<td>Undergraduate Research in Civil and Environmental</td>
<td>1-4</td>
</tr>
<tr>
<td></td>
<td>Engineering</td>
<td></td>
</tr>
</tbody>
</table>

### 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 science, 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, the corporate sector, and for graduate study.

### Requirements

#### Mathematics (26 units minimum)—

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 103</td>
<td>Mathematical Foundations of Computing</td>
<td>5</td>
</tr>
<tr>
<td>CS 109</td>
<td>Introduction to Probability for Computer Scientists</td>
<td>5</td>
</tr>
<tr>
<td>MATH 19</td>
<td>Calculus 1</td>
<td>3</td>
</tr>
<tr>
<td>MATH 20</td>
<td>Calculus 1</td>
<td>3</td>
</tr>
<tr>
<td>MATH 21</td>
<td>Calculus 1</td>
<td>4</td>
</tr>
</tbody>
</table>

Plus two electives

---

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu).
### Science (11 units minimum) –

**Physics 41** Mechanics 4  
**PHYSICS 43** Electricity and Magnetism 4  
Science elective 3  

### Technology in Society (3-5 units) –

One course; course chosen must be on the SoE Approved Courses list at <ughb.stanford.edu> the year taken; see Basic Requirements 4 in the School of Engineering section.

### Engineering Fundamentals (13 units minimum; see Basic Requirement 3 in the School of Engineering section) –

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 106B</td>
<td>5</td>
</tr>
<tr>
<td>or CS 106X</td>
<td></td>
</tr>
<tr>
<td>ENGR 40M</td>
<td>An Intro to Making: What is EE (or ENGR 40A and ENGR 40B) 3-5</td>
</tr>
</tbody>
</table>

Fundamentals Elective (May be an ENGR fundamentals or an additional CS Depth course. See Fig. 3-4 in the UGHB for approved ENGR fundamentals list. May not be any CS 106)

*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.*

### Writing in the Major –

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 181W</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 191W</td>
<td>Writing Intensive Senior Project</td>
</tr>
<tr>
<td>CS 194W</td>
<td>Software Project</td>
</tr>
<tr>
<td>CS 210B</td>
<td>Software Project Experience with Corporate Partners</td>
</tr>
<tr>
<td>CS 294W</td>
<td>Writing Intensive Research Project in Computer Science</td>
</tr>
</tbody>
</table>

### Computer Science Core (15 units) –

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
</tr>
<tr>
<td>or CS 107E</td>
<td>Computer Systems from the Ground Up</td>
</tr>
<tr>
<td>CS 110</td>
<td>Principles of Computer Systems</td>
</tr>
<tr>
<td>CS 161</td>
<td>Design and Analysis of Algorithms</td>
</tr>
</tbody>
</table>

### Senior Project (3 units) –

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 191</td>
<td>Senior Project</td>
</tr>
<tr>
<td>CS 191W</td>
<td>Writing Intensive Senior Project</td>
</tr>
<tr>
<td>CS 194</td>
<td>Software Project</td>
</tr>
<tr>
<td>CS 194H</td>
<td>User Interface Design Project</td>
</tr>
<tr>
<td>CS 194W</td>
<td>Software Project</td>
</tr>
<tr>
<td>CS 210B</td>
<td>Software Project Experience with Corporate Partners</td>
</tr>
<tr>
<td>CS 294</td>
<td>or CS 294W Writing Intensive Research Project in Computer Science</td>
</tr>
</tbody>
</table>

### 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 –

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
</tr>
</tbody>
</table>

Select two courses, each from a different area:

**Area I, AI Methods:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
</tr>
<tr>
<td>CS 238</td>
<td>Decision Making under Uncertainty</td>
</tr>
</tbody>
</table>

**Area II, Natural Language Processing:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 124</td>
<td>From Languages to Information</td>
</tr>
<tr>
<td>CS 224N</td>
<td>Natural Language Processing with Deep Learning</td>
</tr>
<tr>
<td>CS 224S</td>
<td>Spoken Language Processing</td>
</tr>
<tr>
<td>CS 224U</td>
<td>Natural Language Understanding</td>
</tr>
</tbody>
</table>

**Area III, Vision:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 131</td>
<td>Computer Vision: Foundations and Applications</td>
</tr>
<tr>
<td>CS 231A</td>
<td>Computer Vision: From 3D Reconstruction to Recognition</td>
</tr>
<tr>
<td>CS 231N</td>
<td>Convolutional Neural Networks for Visual Recognition</td>
</tr>
</tbody>
</table>

**Area IV, Robotics:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 223A</td>
<td>Introduction to Robotics</td>
</tr>
</tbody>
</table>

Select one additional course from the Areas above or from the following:

**AI Methods:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 157</td>
<td>Computational Logic</td>
</tr>
<tr>
<td>CS 205L</td>
<td>Continuous Mathematical Methods with an Emphasis on Machine Learning</td>
</tr>
<tr>
<td>CS 230</td>
<td>Deep Learning</td>
</tr>
<tr>
<td>CS 236</td>
<td>Deep Generative Models</td>
</tr>
<tr>
<td>STATS 315A</td>
<td>Modern Applied Statistics: Learning</td>
</tr>
<tr>
<td>STATS 315B</td>
<td>Modern Applied Statistics: Data Mining</td>
</tr>
</tbody>
</table>

**Vision:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 231B</td>
<td></td>
</tr>
<tr>
<td>CS 231M</td>
<td></td>
</tr>
<tr>
<td>CS 331A</td>
<td></td>
</tr>
</tbody>
</table>

**Comp Bio:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 262</td>
<td></td>
</tr>
<tr>
<td>CS 279</td>
<td>Computational Biology: Structure and Organization of Biomolecules and Cells</td>
</tr>
<tr>
<td>CS 371</td>
<td>Computational Biology in Four Dimensions</td>
</tr>
<tr>
<td>CS 374</td>
<td></td>
</tr>
</tbody>
</table>

**Information and the Web:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 276</td>
<td>Information Retrieval and Web Search</td>
</tr>
<tr>
<td>CS 224W</td>
<td>Analysis of Networks</td>
</tr>
</tbody>
</table>

**Other:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 151</td>
<td>Logic Programming</td>
</tr>
<tr>
<td>CS 227B</td>
<td>General Game Playing</td>
</tr>
<tr>
<td>CS 277</td>
<td></td>
</tr>
<tr>
<td>CS 379</td>
<td>Interdisciplinary Topics</td>
</tr>
</tbody>
</table>

**Robotics and Control:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 327A</td>
<td>Advanced Robotic Manipulation</td>
</tr>
<tr>
<td>CS 329</td>
<td>Topics in Artificial Intelligence (with advisor approval)</td>
</tr>
<tr>
<td>ENGR 205</td>
<td>Introduction to Control Design Techniques</td>
</tr>
<tr>
<td>EE 209</td>
<td></td>
</tr>
<tr>
<td>MS&amp;E 251</td>
<td>Introduction to Stochastic Control with Applications</td>
</tr>
<tr>
<td>MS&amp;E 351</td>
<td>Dynamic Programming and Stochastic Control</td>
</tr>
</tbody>
</table>

Track Electives: at least three additional courses selected from the Areas and lists above, general CS electives, or the following: 4

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 238</td>
<td>Decision Making under Uncertainty</td>
</tr>
</tbody>
</table>
Biocomputation Track—

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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
<td></td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td></td>
</tr>
<tr>
<td>CS 231A</td>
<td>Computer Vision: From 3D Reconstruction to Recognition</td>
<td></td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 262</td>
<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
<td></td>
</tr>
<tr>
<td>CS 273A</td>
<td>The Human Genome Source Code</td>
<td></td>
</tr>
<tr>
<td>CS 274</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
<td></td>
</tr>
<tr>
<td>CS 275</td>
<td>Translational Bioinformatics</td>
<td></td>
</tr>
<tr>
<td>CS 279</td>
<td>Computational Biology: Structure and Organization of Biomolecules and Cells</td>
<td>3-4</td>
</tr>
</tbody>
</table>

One additional course from the lists above or the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 124</td>
<td>From Languages to Information</td>
<td></td>
</tr>
<tr>
<td>CS 145</td>
<td>Data Management and Data Systems</td>
<td></td>
</tr>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td></td>
</tr>
<tr>
<td>CS 148</td>
<td>Introduction to Computer Graphics and Imaging</td>
<td></td>
</tr>
<tr>
<td>CS 248</td>
<td>Interactive Computer Graphics</td>
<td></td>
</tr>
</tbody>
</table>

One course selected from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 108</td>
<td>Object-Oriented Systems Design</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 124</td>
<td>From Languages to Information</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 131</td>
<td>Computer Vision: Foundations and Applications</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td>3-4</td>
</tr>
<tr>
<td>or CS 140E</td>
<td>Operating systems design and implementation</td>
<td></td>
</tr>
</tbody>
</table>
School of Engineering

20

CS 247 Human-Computer Interaction Design Studio 3-4
CS 248 Interactive Computer Graphics 3-4
CS 251 Cryptocurrencies and blockchain technologies 3
CS 252 Analysis of Boolean Functions 3
CS 254 Computational Complexity 3
CS 255 Introduction to Cryptography 3
CS 261 Optimization and Algorithmic Paradigms 3
CS 262
CS 263 Algorithms for Modern Data Models 3
CS 264 Beyond Worst-Case Analysis 3
CS 265 Randomized Algorithms and Probabilistic Analysis 3
CS 266
CS 267
CS 269I Incentives in Computer Science 3
CS 270 Modeling Biomedical Systems: Ontology, Terminology, Problem Solving 3
CS 272 Introduction to Biomedical Informatics Research Methodology 3-5
CS 273A The Human Genome Source Code 3
CS 273B Deep Learning in Genomics and Biomedicine 3
CS 274 Representations and Algorithms for Computational Molecular Biology 3-4
CS 275 Translational Bioinformatics 4
CS 276 Information Retrieval and Web Search 3
CS 278 Social Computing 3
CS 279 Computational Biology: Structure and Organization of Biomolecules and Cells 3
CS 348B Computer Graphics: Image Synthesis Techniques 3-4
CS 348C Computer Graphics: Animation and Simulation 3
CS 348K Visual Computing Systems 3-4
CS 371 Computational Biology in Four Dimensions 3
CS 374
CME 108 Introduction to Scientific Computing 3
EE 180 Digital Systems Architecture 4
EE 263 Introduction to Linear Dynamical Systems 3
EE 282 Computer Systems Architecture 3
EE 364A Convex Optimization I 3
BIOE 101 Systems Biology 3
MS&E 152 Introduction to Decision Analysis 3-4
MS&E 252 Decision Analysis I: Foundations of Decision Analysis 3-4
STATS 206 Applied Multivariate Analysis 3
STATS 315A Modern Applied Statistics: Learning 2-3
STATS 315B Modern Applied Statistics: Data Mining 2-3
GENE 211 Genomics 3
One course selected from the list above or the following:
CHEMENG 150 Biochemical Engineering 3
CHEMENG 174 Environmental Microbiology I 3
APPPHYS 294 Cellular Biophysics 3
BIO 104 Advance Molecular Biology: Epigenetics and Proteostasis 5
BIO 118 4
BIO 188 4
BIO 189 4
BIO 214 Advanced Cell Biology 4
BIO 217 4
BIO 230 Molecular and Cellular Immunology 4
CHEM 141 The Chemical Principles of Life I 4
CHEM 171 Physical Chemistry I 4
BIOC 218 4
BIOC 241 Biological Macromolecules 3-5
One course from the following:
BIOE 220 Introduction to Imaging and Image-based Human Anatomy 3
CHEMENG 150 Biochemical Engineering 3
CHEMENG 174 Environmental Microbiology I 3
CS 262 3
CS 274 Representations and Algorithms for Computational Molecular Biology 3-4
CS 279 Computational Biology: Structure and Organization of Biomolecules and Cells 3
CS 371 Computational Biology in Four Dimensions 3
CS 374
ME 281 Biomechanics of Movement 3
APPPHYS 294
BIO 104 Advance Molecular Biology: Epigenetics and Proteostasis 5
BIO 112 Human Physiology 4
BIO 118 4
BIO 158 Developmental Neurobiology 4
BIO 183 Theoretical Population Genetics 3
BIO 188 4
BIO 189 4
BIO 214 Advanced Cell Biology 4
BIO 217 4
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 230</td>
<td>Molecular and Cellular Immunology</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 171</td>
<td>Physical Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 218</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL 241</td>
<td>Biological Macromolecules</td>
<td>3-5</td>
</tr>
<tr>
<td>DBIO 210</td>
<td>Developmental Biology</td>
<td>4</td>
</tr>
<tr>
<td>GENE 211</td>
<td>Genomics</td>
<td>3</td>
</tr>
<tr>
<td>SURG 101</td>
<td>Regional Study of Human Structure</td>
<td>5</td>
</tr>
</tbody>
</table>

**Computer Engineering Track—**

For this track there is a 10 unit minimum for ENGR Fundamentals and a 29 unit minimum for Depth (for track and elective courses)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 108</td>
<td>Digital System Design</td>
<td>6-8</td>
</tr>
<tr>
<td>EE 180</td>
<td>Digital Systems Architecture</td>
<td></td>
</tr>
<tr>
<td>EE 101A</td>
<td>Circuits I</td>
<td></td>
</tr>
<tr>
<td>EE 101B</td>
<td>Circuits II</td>
<td></td>
</tr>
<tr>
<td>EE 102A</td>
<td>Signal Processing and Linear Systems I</td>
<td></td>
</tr>
<tr>
<td>EE 102B</td>
<td>Signal Processing and Linear Systems II</td>
<td></td>
</tr>
</tbody>
</table>

Select two of the following: 8

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td></td>
</tr>
<tr>
<td>or CS 140E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE 109</td>
<td>Digital Systems Design Lab</td>
<td></td>
</tr>
<tr>
<td>EE 271</td>
<td>Introduction to VLSI Systems</td>
<td></td>
</tr>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td></td>
</tr>
<tr>
<td>or CS 140E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 144</td>
<td>Introduction to Computer Networking</td>
<td></td>
</tr>
<tr>
<td>CS 149</td>
<td>Parallel Computing</td>
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<tr>
<td>CS 190</td>
<td>Software Design Studio</td>
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<tr>
<td>CS 217</td>
<td>Hardware Accelerators for Machine Learning</td>
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<tr>
<td>CS 240E</td>
<td>Advanced Topics in Networking</td>
<td></td>
</tr>
<tr>
<td>CS 244</td>
<td>Advanced Topics in Networking</td>
<td></td>
</tr>
<tr>
<td>EE 273</td>
<td>Digital Systems Engineering</td>
<td></td>
</tr>
<tr>
<td>EE 282</td>
<td>Computer Systems Architecture</td>
<td></td>
</tr>
</tbody>
</table>

Select two of the following:

- 1) Digital Systems Concentration:
  - CS 140 Operating Systems and Systems Programming
  - EE 109 Digital Systems Design Lab
  - EE 271 Introduction to VLSI Systems

- 2) Robotics and Mechatronics Concentration:
  - CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning
  - CS 223A Introduction to Robotics
  - ME 210 Introduction to Mechatronics
  - ENGR 105 Feedback Control Design

- 3) Networking Concentration:
  - CS 140 Operating Systems and Systems Programming and Introduction to Computer Networking (CS 140E can substitute for CS 140)

Select one of the following: 5

- CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning
- 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 146 Introduction to Game Design and Development
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- or CS 131 Computer Vision: Foundations and Applications
- CS 233 Geometric and Topological Data Analysis
- CS 268 Geometric Algorithms
- CS 348C Computer Graphics: Animation and Simulation
- CS 348K Visual Computing Systems
- 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: 4

- ARTSTUDI 160 Intro to Digital / Physical Design
- ARTSTUDI 170 PHOTOGRAPHY I: BLACK AND WHITE
- ARTSTUDI 179 Digital Art I
- CME 302 Numerical Linear Algebra
- CME 306 Numerical Solution of Partial Differential Equations
- EE 168 Introduction to Digital Image Processing
- 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 Image Systems Engineering

**Human-Computer Interaction Track—**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td>4</td>
</tr>
<tr>
<td>CS 247</td>
<td>Human-Computer Interaction Design Studio</td>
<td>4</td>
</tr>
</tbody>
</table>

Any three of the following:

- CS 142 Web Applications
- CS 146 Introduction to Game Design and Development
- CS 148 Introduction to Computer Graphics and Imaging
- CS 194H User Interface Design Project
- CS 206 Exploring Computational Journalism
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 210A</td>
<td>Software Project Experience with Corporate Partners</td>
</tr>
<tr>
<td>CS 278</td>
<td>Social Computing</td>
</tr>
<tr>
<td>CS 376</td>
<td>Human-Computer Interaction Research</td>
</tr>
<tr>
<td>Any CS 377 'Topics in HCI' of three or more units</td>
<td></td>
</tr>
<tr>
<td>CS 448B</td>
<td>Data Visualization</td>
</tr>
<tr>
<td>ME 216M</td>
<td>Introduction to the Design of Smart Products</td>
</tr>
</tbody>
</table>

At least two additional courses from above list, the general CS electives list, or the following:

- Any d.school class of 3 or more units
- Any class of 3 or more units at hci.stanford.edu under the 'courses' link

### Communication-
- COMM 121  Behavior and Social Media
- COMM 124  Lies, Trust, and Tech
  or COMM 22 Lies, Trust, and Tech
- COMM 140  or COMM 240
- COMM 154  The Politics of Algorithms
- COMM 166  Virtual People
- COMM 169  or COMM 26
- COMM 172  Media Psychology
  or COMM 27 Media Psychology
- COMM 182
- COMM 254  The Politics of Algorithms
- 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 Performatve Practices
  ARTSTUDI 168 Data as Material
  ARTSTUDI 264 Advanced Interaction Design
  ARTSTUDI 266 Sculptural Screens / Malleable Media
  ARTSTUDI 267 Emerging Technology Studio
- Sym Sys-
  SYMSYS 245 Cognition in Interaction Design
- Psychology-
  PSYCH 30  Introduction to Perception
  PSYCH 35  Minds and Machines
  PSYCH 45  Introduction to Learning and Memory
  PSYCH 50  Introduction to Cognitive Neuroscience
  PSYCH 60  Introduction to Developmental Psychology
  PSYCH 70  Self and Society: Introduction to Social Psychology
  PSYCH 75  Introduction to Cultural Psychology
  PSYCH 80  Introduction to Personality and Affective Science
  PSYCH 90  Introduction to Clinical Psychology
  PSYCH 95  Introduction to Abnormal Psychology
  PSYCH 131
  PSYCH 154  Judgment and Decision-Making
- Empirical Methods-
  COMM 314  Ethnographic Methods
  MS&E 125  Introduction to Applied Statistics
  PSYCH 251  Experimental Methods

### 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
- MUSIC 256A  Music, Computing, Design I: The Art of Design

### Information Track—

**Units**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 124</td>
<td>From Languages to Information</td>
<td>4</td>
</tr>
<tr>
<td>CS 145</td>
<td>Data Management and Data Systems</td>
<td>4</td>
</tr>
<tr>
<td>1) Information-based AI applications</td>
<td>6-9</td>
<td></td>
</tr>
<tr>
<td>CS 224N</td>
<td>Natural Language Processing with Deep Learning</td>
<td></td>
</tr>
<tr>
<td>CS 224S</td>
<td>Spoken Language Processing</td>
<td></td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td></td>
</tr>
<tr>
<td>CS 233</td>
<td>Geometric and Topological Data Analysis</td>
<td></td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
<td></td>
</tr>
<tr>
<td>2) Database and Information Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td></td>
</tr>
<tr>
<td>CS 140E</td>
<td>Operating systems design and implementation</td>
<td></td>
</tr>
<tr>
<td>CS 142</td>
<td>Web Applications</td>
<td></td>
</tr>
<tr>
<td>CS 151</td>
<td>Logic Programming</td>
<td></td>
</tr>
<tr>
<td>CS 245</td>
<td>Database Systems Principles</td>
<td></td>
</tr>
<tr>
<td>CS 246</td>
<td>Mining Massive Data Sets</td>
<td></td>
</tr>
<tr>
<td>CS 341</td>
<td>Project in Mining Massive Data Sets</td>
<td></td>
</tr>
<tr>
<td>CS 345</td>
<td>(Offered occasionally)</td>
<td></td>
</tr>
<tr>
<td>3) Information Systems in Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 262</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 270</td>
<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
<td></td>
</tr>
</tbody>
</table>
Systems Track —

Units
CS 140 Operating Systems and Systems Programming 4
or CS 140E Operating systems design and implementation
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 Data Management and Data Systems
CS 149 Parallel Computing
CS 155 Computer and Network Security
CS 190 Software Design Studio
CS 217 Hardware Accelerators for Machine Learning
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: 4
CS 241 Embedded Systems Workshop
CS 316 Advanced Multi-Core Systems
CS 341 Project in Mining Massive Data Sets
CS 343 (Not given this year)
CS 344 Topics in Mining Massive Data Sets (3 or more units, any suffix)
CS 345 (Advanced Topics in Database Systems - 3 or more units, any suffix)
CS 349 Topics in Programming Systems (with permission of undergraduate advisor)
CS 448 Topics in Computer Graphics
EE 108 Digital System Design
EE 382C Interconnection Networks
EE 384A Internet Routing Protocols and Standards
EE 384B
EE 384C Wireless Local and Wide Area Networks
EE 384S Performance Engineering of Computer Systems & Networks

Theory Track —

Units
CS 154 Introduction to Automata and Complexity Theory 4
Select one of the following: 3
CS 168 The Modern Algorithmic Toolbox
CS 255 Introduction to Cryptography
CS 261 Optimization and Algorithmic Paradigms
CS 264 Beyond Worst-Case Analysis

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
or CS 140E Operating systems design and implementation
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 190 Software Design Studio
CS 242 Programming Languages
CS 244 Advanced Topics in Networking
EE 180 Digital Systems Architecture

Select one of the following: 3-4
CS 221 Artificial Intelligence: Principles and Techniques
CS 223A Introduction to Robotics
CS 228 Probabilistic Models: Principles and Techniques
CS 229 Machine Learning
CS 231A Computer Vision: From 3D Reconstruction to Recognition

Individual Designed Track—
Students may propose an individually designed track. Proposals should include a minimum of 25 units and seven courses, at least four of which must be CS courses numbered 100 or above. See Handbook for Undergraduate Engineering Programs for further information.

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 OR MATH 41 and MATH 42 OR AP Calculus Credit may be used as long as at least 26 MATH units are taken. AP Calculus Credit must be approved by the School of Engineering.

2. The math electives list consists of: MATH 51, MATH 52, MATH 53, MATH 104, MATH 108, MATH 109, MATH 110, MATH 113; CS 157, CS 205L; PHIL 151; CME 100, CME 102, CME 103 (or EE103), CME 104. 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 (Fig. 4-2 in the UGHB), PSYCH 30, or AP Chemistry Credit. 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 Chemistry Credit and AP Physics Credit must be approved by the School of Engineering.


5. CS 205L is strongly 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.

6. Independent study projects (CS 191 Senior Project or 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.

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

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 disciplinary areas beyond the core, including hardware and software, information systems and science, and physical technology and science, as well as electives in multidisciplinary areas, including bio-electronics 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 1

Select one sequence: May also be satisfied with AP Calculus.  

10

MATH 19 & MATH 20 Calculus
MATH 21 & Calculus

Select one 2-course sequence:  

10

CME 101 & CME 102 Vector Calculus for Engineers
CME 101 Linear Algebra, Multivariable Calculus, and Modern Applications and Ordinary Differential Equations for Engineers (Same as ENGR 154 and ENGR 155A)

MATH 51 & MATH 53 Linear Algebra, Multivariable Calculus, and Modern Applications and Ordinary Differential Equations with Linear Algebra 2

EE Math. One additional 100-level course. Select one:  

3

EE 103 Introduction to Matrix Methods (Preferred) 1
MATH 113 Linear Algebra and Matrix Theory

CS 103 Mathematical Foundations of Computing

Statistics/Probability. Select one:  

3-4

EE 178 Probabilistic Systems Analysis (Preferred)
CS 109 Introduction to Probability for Computer Scientists

Science 1

Minimum 12 units

Select one sequence:  

12
Disciplinary Area.
Select one. Students may select their Design course from any
Design Course disciplinary area electives.

Minimum 17 units, 5 courses: 1-2 Required, 1 WIM/Design and 2-3
Disciplinary Area
Physics of Electrical Engineering.
Undergraduate Handbook, Approved List.
not allowed for the Fundamentals elective. Choose from table in
ENGR 40A and ENGR 40B or ENGR 40M (recommended before
Choose one Fundamental from the Approved List; Recommended:
ENGR 70B
CS 106B/
Select one:
2 courses required; minimum 10 units
Engineering Fundamentals
Disciplinary Area (minimum 17 units), Electives (maximum
17 units, restrictions apply).

Electives
Minimum 17 units. The elective units should be sufficient to
meet the 60 unit total for the major, over and above the 40 units
of Math and Science. Depending on units completed in the
Disciplinary Area, elective units will be in the range of 17 units or
less. Students may select electives from the disciplinary areas;
from the multidisciplinary elective areas; or any combination of
disciplinary and multidisciplinary areas. May include up to two
additional Engineering Fundamentals, any CS 193 course and any
letter graded EE courses (minus any previously noted restrictions).
Freshman and Sophomore seminars, EE 191 and CS 106A do not
count toward the 60 units. Students may have fewer elective units if
they have more units in their disciplinary area.

Math 41 and Math 42 are no longer offered and have been replaced by
MATH 19, MATH 20, and MATH 21. If used for math, EE 103 may
not be used as an EE disciplinary elective. PHYSICS 41E may be used
in place of PHYSICS 41.

MATH 52 may be taken in place of MATH 51. CME 102 can be taken in
place of MATH 53.

EE 42 may be used in place of PHYSICS 43. CME 102 can be used in
place of PHYSICS 43. There are no prerequisites for ENGR 40A and ENGR 40B
or ENGR 40M.

For upper division students, a 200-level seminar in their disciplinary
area will be accepted, on petition.

Students may petition to have either PHYSICS 65 or the combination of
PHYSICS 45 and PHYSICS 70 count as an alternative to EE 65.

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.

To satisfy Design, must take

A course may only be counted towards one requirement; it may not
be double-counted. All courses taken for the major must be taken
for 4 units and
or the combination
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Disciplinary GPA for all courses in Engineering Fundamentals and
Electives must be at least 3.0.

Disciplinary Areas

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and Software</td>
</tr>
<tr>
<td>EE 103</td>
</tr>
<tr>
<td>EE 104</td>
</tr>
<tr>
<td>EE 180</td>
</tr>
<tr>
<td>EE 107</td>
</tr>
</tbody>
</table>

**Technical Writing**

One course, see Basic Requirement 4 in the School of Engineering
section. The course taken must be on the School of Engineering
Approved Courses list, Fig 4-3, the year it is taken.

**Engineering Topics**

Minimum 60 units comprised of: Engineering Fundamentals
(minimum 10 units), Core Electrical Engineering Courses (minimum
16 units) Disciplinary Area (minimum 17 units), Electives (maximum
17 units, restrictions apply).

**Engineering Fundamentals**

2 courses required; minimum 10 units
Select one:

- CS 106B/ Programming Abstractions
- ENGR 70B
- or CS 106X/ Programming Abstractions (Accelerated)
- ENGR 70X

Choose one Fundamental from the Approved List; Recommended:

- ENGR 40A and ENGR 40B or ENGR 40M (recommended before
taking EE 101A); taking CS 106A or a second ENGR 40-series course not allowed for the Fundamentals elective. Choose from table in
Undergraduate Handbook, Approved List.

**Core Electrical Engineering Courses**

- EE 100 The Electrical Engineering Profession
- EE 101A Circuits I
- EE 102A Signal Processing and Linear Systems I
- EE 108 Digital System Design
- Physics of Electrical Engineering.
- EE 65 Modern Physics for Engineers

**Disciplinary Area**

Minimum 17 units, 5 courses: 1-2 Required, 1 WIM/Design and 2-3
disciplinary area electives.

**Writing in the Major (WIM)**

3-5
Select one. A single course can concurrently meet the WIM and Design Requirements.

- 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)
- EE 264W Digital Signal Processing (WIM/Design)
- EE 267W Virtual Reality (WIM/Design)
- CS 194W Software Project (WIM/Design)

**Design Course**

3-5
Select one. Students may select their Design course from any
Disciplinary Area.

- EE 109 Digital Systems Design Lab (WIM/Design)
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 109</td>
<td>Digital Systems Design Lab (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 118</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics (Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 264</td>
<td>Digital Signal Processing (Design)</td>
<td>3-4</td>
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<tr>
<td>EE 264W</td>
<td>Digital Signal Processing (WIM/Design)</td>
<td>5</td>
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<tr>
<td>EE 267</td>
<td>Virtual Reality (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 267W</td>
<td>Virtual Reality (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 271</td>
<td>Introduction to VLSI Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 272</td>
<td>Design Projects in VLSI Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 273</td>
<td>Digital Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 282</td>
<td>Computer Systems Architecture</td>
<td>3</td>
</tr>
<tr>
<td>EE 285</td>
<td>Embedded Systems Workshop</td>
<td>2</td>
</tr>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems (Required prerequisite for EE 180, CS 107E preferred)</td>
<td>3-5</td>
</tr>
<tr>
<td>or CS 107E</td>
<td>Computer Systems from the Ground Up</td>
<td></td>
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<tr>
<td>CS 108</td>
<td>Object-Oriented Systems Design</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 110</td>
<td>Principles of Computer Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 131</td>
<td>Computer Vision: Foundations and Applications</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 143</td>
<td>Compilers</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 144</td>
<td>Introduction to Computer Networking</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 145</td>
<td>Data Management and Data Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 148</td>
<td>Introduction to Computer Graphics and Imaging</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 149</td>
<td>Parallel Computing</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 155</td>
<td>Computer and Network Security</td>
<td>3</td>
</tr>
<tr>
<td>CS 194W</td>
<td>Software Project (WIM/Design)</td>
<td>3</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 223A</td>
<td>Introduction to Robotics</td>
<td>3</td>
</tr>
<tr>
<td>CS 224N</td>
<td>Natural Language Processing with Deep Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 225A</td>
<td>Experimental Robotics</td>
<td>3</td>
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<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
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<tr>
<td>CS 231A</td>
<td>Computer Vision: From 3D Reconstruction to Recognition</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 231N</td>
<td>Convolutional Neural Networks for Visual Recognition</td>
<td>3-4</td>
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<tr>
<td>CS 241</td>
<td>Embedded Systems Workshop</td>
<td>2</td>
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<tr>
<td>CS 244</td>
<td>Advanced Topics in Networking</td>
<td>3-4</td>
</tr>
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</table>

**Information Systems and Science**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 102B</td>
<td>Signal Processing and Linear Systems II (Required)</td>
<td>4</td>
</tr>
<tr>
<td>EE 103</td>
<td>Introduction to Matrix Methods</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 104</td>
<td>Introduction to Machine Learning</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 107</td>
<td>Embedded Networked Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 118</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>EE 124</td>
<td>Introduction to Neuroelectrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 133</td>
<td>Analog Communications Design Laboratory (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 168</td>
<td>Introduction to Digital Image Processing (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 169</td>
<td>Introduction to Bioimaging</td>
<td>3</td>
</tr>
<tr>
<td>EE 179</td>
<td>Analog and Digital Communication Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 261</td>
<td>The Fourier Transform and Its Applications</td>
<td>3</td>
</tr>
<tr>
<td>EE 262</td>
<td>Two-Dimensional Imaging (Design)</td>
<td>3</td>
</tr>
<tr>
<td>EE 263</td>
<td>Introduction to Linear Dynamical Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 264</td>
<td>Digital Signal Processing (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 264W</td>
<td>Digital Signal Processing (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 267</td>
<td>Virtual Reality (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 278</td>
<td>Introduction to Statistical Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EE 279</td>
<td>Introduction to Digital Communication</td>
<td>3</td>
</tr>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>ENGR 105</td>
<td>Feedback Control Design</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 205</td>
<td>Introduction to Control Design Techniques</td>
<td>3</td>
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**Physical Technology and Science**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
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<tbody>
<tr>
<td>EE 101B</td>
<td>Circuits II (Required)</td>
<td>4</td>
</tr>
<tr>
<td>EE 103</td>
<td>Introduction to Matrix Methods</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 107</td>
<td>Embedded Networked Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 114</td>
<td>Fundamentals of Analog Integrated Circuit Design</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 116</td>
<td>Semiconductor Devices for Energy and Electronics</td>
<td>3</td>
</tr>
<tr>
<td>EE 118</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>EE 124</td>
<td>Introduction to Neuroelectrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 133</td>
<td>Analog Communications Design Laboratory (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 134</td>
<td>Introduction to Photonics (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 142</td>
<td>Engineering Electromagnetics</td>
<td>3</td>
</tr>
<tr>
<td>EE 153</td>
<td>Power Electronics (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 212</td>
<td>Integrated Circuit Fabrication Processes</td>
<td>3</td>
</tr>
<tr>
<td>EE 214B</td>
<td>Advanced Integrated Circuit Design</td>
<td>3</td>
</tr>
<tr>
<td>EE 216</td>
<td>Principles and Models of Semiconductor Devices</td>
<td>3</td>
</tr>
<tr>
<td>EE 222</td>
<td>Applied Quantum Mechanics I</td>
<td>3</td>
</tr>
<tr>
<td>EE 223</td>
<td>Applied Quantum Mechanics II</td>
<td>3</td>
</tr>
<tr>
<td>EE 228</td>
<td>Basic Physics for Solid State Electronics</td>
<td>3</td>
</tr>
<tr>
<td>EE 236A</td>
<td>Modern Optics</td>
<td>3</td>
</tr>
<tr>
<td>EE 236B</td>
<td>Guided Waves</td>
<td>3</td>
</tr>
<tr>
<td>EE 242</td>
<td>Electromagnetic Waves</td>
<td>3</td>
</tr>
<tr>
<td>EE 247</td>
<td>Introduction to Optical Fiber Communications</td>
<td>3</td>
</tr>
<tr>
<td>EE 264</td>
<td>Digital Signal Processing (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 264W</td>
<td>Digital Signal Processing (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 267</td>
<td>Virtual Reality (Design)</td>
<td>3-4</td>
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<tr>
<td>EE 267W</td>
<td>Virtual Reality (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 271</td>
<td>Introduction to VLSI Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 272</td>
<td>Design Projects in VLSI Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 273</td>
<td>Digital Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 282</td>
<td>Computer Systems Architecture</td>
<td>3</td>
</tr>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>ENGR 105</td>
<td>Feedback Control Design</td>
<td>3</td>
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**Multidisciplinary Area Electives**

**Bio-electronics and Bio-imaging**

<table>
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<tr>
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<th>Course Name</th>
<th>Units</th>
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<tr>
<td>EE 101B</td>
<td>Circuits II (Required)</td>
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<tr>
<td>EE 102B</td>
<td>Signal Processing and Linear Systems II (Required)</td>
<td>4</td>
</tr>
<tr>
<td>EE 107</td>
<td>Embedded Networked Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 124</td>
<td>Introduction to Neuroelectrical Engineering</td>
<td>3</td>
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<tr>
<td>EE 134</td>
<td>Introduction to Photonics (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 168</td>
<td>Introduction to Digital Image Processing (WIM/Design)</td>
<td>4</td>
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</table>

**Energy and Environment**

<table>
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<td>EE 169</td>
<td>Introduction to Bioimaging</td>
<td>3</td>
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<tr>
<td>EE 225</td>
<td>Biochips and Medical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 248</td>
<td>Neuroengineering Laboratory</td>
<td>3</td>
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<td>BIOE 131</td>
<td>Ethics in Bioengineering</td>
<td>3</td>
</tr>
<tr>
<td>MED 275B</td>
<td>Biodesign Fundamentals</td>
<td>4</td>
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</table>
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, quantum science & engineering, 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

Mathematics

Select one of the following sequences:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Units</th>
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<tr>
<td>MATH 51 &amp; MATH 52</td>
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<tr>
<td>CME 100 &amp; CME 104</td>
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<tr>
<td>MATH 53 or CME 102</td>
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<tr>
<td>MATH 131P</td>
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Science

Select one of the following sequences:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Units</th>
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<tbody>
<tr>
<td>PHYSICS 41</td>
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<td>PHYSICS 43</td>
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<td>PHYSICS 67</td>
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<tr>
<td>PHYSICS 45</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 46</td>
<td>1</td>
</tr>
<tr>
<td>PHYSICS 70</td>
<td>4</td>
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</table>

Technology in Society

One course required; course must be on the School of Engineering Approved List, Fig 4-3 in the UGHB, the year it is taken. See Basic Requirement 4.

Engineering Fundamentals

Two courses minimum (CS 106A or X recommended) 2

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
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<td>6-10</td>
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Engineering Physics Depth (core)

Advanced Mathematics:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tr>
<td>EE 261</td>
<td>3-5</td>
</tr>
<tr>
<td>PHYSICS 112</td>
<td></td>
</tr>
<tr>
<td>CS 109</td>
<td>6-8</td>
</tr>
<tr>
<td>CME 106</td>
<td></td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PHYSICS 120</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 242A</td>
<td></td>
</tr>
<tr>
<td>Intermediate Electricity and Magnetism</td>
<td>3</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>6-8</td>
</tr>
<tr>
<td>PHYSICS 120</td>
<td></td>
</tr>
<tr>
<td>CME 101</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td></td>
</tr>
<tr>
<td>EE 142</td>
<td></td>
</tr>
</tbody>
</table>

Numerical Methods

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 206</td>
<td>3-4</td>
</tr>
</tbody>
</table>
### Electronics Lab
Select one of the following: 3-5
- ENGR 40A  Introductory Electronics
- ENGR 40B  and Introductory Electronics Part II (ENGR 40A alone is not allowed)
- EE 101B  Circuits II
- EE 122A
- PHYSICS 105  Intermediate Physics Laboratory I: Analog Electronics
- APPPHYS 207  Laboratory Electronics

### Writing in the Major (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  Energy Materials 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 Photonics or other specialty)

### Quantum Mechanics
Select one of the following sequences: 6-8
- EE 222  Applied Quantum Mechanics I
- EE 223  and Applied Quantum Mechanics II
- PHYSICS 130  Quantum Mechanics I
- & PHYSICS 131 and Quantum Mechanics II

### Thermodynamics and Statistical Mechanics
- PHYSICS 170  Thermodynamics, Kinetic Theory, and Statistical Mechanics I
- & PHYSICS 171  and Thermodynamics, Kinetic Theory, and Statistical Mechanics II
- 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
See Undergraduate Engineering Handbook for important details. 9-12
Select three courses from one specialty area:

#### Aerospace Physics:
- AA 203  Introduction to Optimal Control and Dynamic Optimization
- 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  100% Clean, Renewable Energy and Storage for Everything
- EE 153  Power Electronics
- EE 155  Green Electronics
- EE 293A
- 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
- BIO 41
- BIO 42  Physical Biology
- BIO 44  Fundamentals for Engineering Biology Lab
- BIO 101  Systems Biology
- BIO 103  Systems Physiology and Design
- BIO 123  Biomedical System Prototyping Lab
- BIO 211  Biophysics of Multi-cellular Systems and Amorphous Computing
- BIO 214  Representations and Algorithms for Computational Molecular Biology
- EE 169  Introduction to Bioimaging
- or EE 369A  Medical Imaging Systems I

#### Computational Science:
- CME 212  Advanced Software Development 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

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>CS 103</td>
<td>Mathematical Foundations of Computing</td>
</tr>
<tr>
<td>CS 154</td>
<td>Introduction to Automata and Complexity Theory</td>
</tr>
<tr>
<td>CS 161</td>
<td>Design and Analysis of Algorithms</td>
</tr>
<tr>
<td>CS 205A</td>
<td></td>
</tr>
<tr>
<td>CS 205B</td>
<td></td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>STATS 202</td>
<td>Data Mining and Analysis</td>
</tr>
<tr>
<td>STATS 213</td>
<td>Introduction to Graphical Models</td>
</tr>
<tr>
<td>PHYSICS 282</td>
<td>Introduction to Modern Atomic Physics and Quantum Optics</td>
</tr>
</tbody>
</table>

**Quantum Science & Engineering**

- PHYSICS 282: Introduction to Modern Atomic Physics and Quantum Optics
- PHYSICS 231: Graduate Quantum Mechanics II
- PHYSICS 230: Graduate Quantum Mechanics I
- PHYSICS 134: Advanced Topics in Quantum Mechanics
- PHYSICS 67: Introduction to Laboratory Physics
- PHYSICS 44: Electricity and Magnetism Lab
- PHYSICS 234: Photonics Laboratory
- PHYSICS 236C: Lasers
- PHYSICS 243: Semiconductor Optoelectronic Devices
- PHYSICS 340: Optical Micro- and Nano-Cavities
- APPPHYS 203: Atoms, Fields and Photons
- APPPHYS 225: Probability and Quantum Mechanics
- APPPHYS 383: Computational Complexity
- EE 234: Photonics Laboratory
- EE 236C: Lasers
- EE 243: Semiconductor Optoelectronic Devices
- CS 229: Machine Learning
- CS 224: Computational Complexity
- CS 225: Introduction to Graphical Models

**Total Units:** 93-119

---

**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
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 AA 190 or 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 one signed, single-sided copy to the student services officer by May 15. Students are sent email instructions on how to archive a permanent electronic copy in Terman Engineering library.

**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.

**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...

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.
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 twenty-first 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

**Technology in Society (TIS)**

One 3-5 unit course required, course chosen must be on the SoE Approved Courses list at e.g "<ughes.stanford.edu> the year taken; see Basic Requirement 4

**Engineering Fundamentals**

Two courses minimum (see Basic Requirement 3), including:

- ENGR 70A Programming Methodology 5
- ENGR 14 Intro to Solid Mechanics 3

**Fundamental Tools/Skills**

- in visual, oral/written communication, and modeling/analysis 9

**Specialty Courses, in either**

- Coastal environments (see below) 40
- or freshwater environments (see below)
- or urban environments (see below)

**Total Units** 96-98

1. Math must include CME 100 Vector Calculus for Engineers (or MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications), 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 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:

1. CEE 1 Introduction to Environmental Systems Engineering;
2. at least one visual communication class from CEE 31 Accessing Architecture Through Drawing / CEE 31Q Accessing Architecture Through Drawing, CEE 133H Drawing in the Urban Environment, ME 101 Visual Thinking, ME 110 Design Sketching, ARTSTUDI 160 Intro to Digital / Physical Design, or OSPPARS 44 EAP Analytical Drawing and Graphic Art;
3. at least one oral/written communication class from ENGR 103 Public Speaking, ENGR 102W Technical and Professional Communication, ENGR 202W Technical Communication, CEE 151 Negotiation, CEE 175P Persuasive Communication for Environmental Scientists, Practitioners, and Entrepreneurs, EARTHSYS 191 Concepts in Environmental Communication or EARTHSYS 200 Environmental Communication in Action: The SAGE Project;
4. at least one modeling/analysis class from CEE 101D Computations in Civil and Environmental Engineering(or CEE 101S) if not counted as Math, CEE 120A Building Information Modeling Workshop (or CEE 120S Building Information Modeling Special Study), CEE 146S Engineering Economics and Sustainability, CEE 155 Introduction to Sensing Networks for CEE, CEE 226 Life Cycle Assessment for Complex Systems, CEE 229 Methods in Urban Systems, CME 211 Software Development for Scientists and Engineers, CS 102 Big Data - Tools and Techniques, EARTHSYS 142 Remote Sensing of Land, EARTHSYS 144 Fundamentals of Geographic Information Science (GIS), ENGR 150 Data Challenge Lab, ESS 214 Introduction to geostatistics and modeling of spatial uncertainty, or OSPCPTWN 13 Engineering Risk Analysis (Win 18-19 only)

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

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**Urban Environments Focus Area (37 units)**

**Required**

- CEE 100 Managing Sustainable Building Projects 4
- CEE 101B Mechanics of Fluids 4
- CEE 146S Engineering Economics and Sustainability 3
- 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
- CEE 120B Building Information Modeling Workshop 2-4
- CEE 130 Architectural Design: 3-D Modeling, Methodology, and Process 5
- CEE 156 Building Systems 4

**Energy Systems**

- CEE 107A Understanding Energy 4-5
- CEE 176B 100% Clean, Renewable Energy and Storage for Everything 3-4
- ENERGY 104 Sustainable Energy for 9 Billion 3
- CEE 173S Electricity Economics 3
- ENERGY 171 Energy Infrastructure, Technology and Economics 3

**Water Systems**

- CEE 165C Water Resources Management 3
- or OSPSANTG 76 Urban Water (Spr 18-19 only) 4
- CEE 166A Watersheds and Wetlands 4
- CEE 166B Floods and Dams and Aqueducts 4
- CEE 174A Providing Safe Water for the Developing and Developed World 3
- CEE 174B Wastewater Treatment: From Disposal to Resource Recovery 3

**Urban Planning, Design, Analysis**

- CEE 6 Physics of Cities 3
- CEE 230 Urban Development and Governance 3
- CEE 265E Adaptation to Sea Level Rise and Extreme Weather Events 3
- or EARTHSYS 238 Land Use Law 3
- CEE 177L Smart Cities & Communities 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
- or URBANST 174 Defining Smart Cities: Visions of Urbanism for the 21st Century 3-4

**Capstone (one class required)**

- CEE 112A Industry Applications of Virtual Design & Construction 3-4
- CEE 122A Computer Integrated Architecture/Engineering/Construction 2
- and CEE 122B Computer Integrated A/E/C 2
- CEE 131D Urban Design Studio 5
<table>
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<th>Course Title</th>
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<tbody>
<tr>
<td>CEE 141A</td>
<td>Infrastructure Project Development</td>
<td>3</td>
</tr>
<tr>
<td>CEE 141B</td>
<td>Infrastructure Project Delivery</td>
<td>3</td>
</tr>
<tr>
<td>CEE 224X</td>
<td>Disasters, Decisions, Development in Sustainable Urban Systems (CEE)</td>
<td>3-5</td>
</tr>
<tr>
<td>CEE 224Y</td>
<td>Sustainable Urban Systems Project</td>
<td>3-5</td>
</tr>
<tr>
<td>CEE 224Z</td>
<td>Sustainable Urban Systems Project</td>
<td>3-5</td>
</tr>
<tr>
<td>CEE 226E</td>
<td>Advanced Topics in Integrated, Energy-Efficient Building Design</td>
<td>3</td>
</tr>
<tr>
<td>CEE 235</td>
<td>CapaCity Design Studio</td>
<td>5</td>
</tr>
<tr>
<td>CEE 243</td>
<td>Intro to Urban Sys Engrg</td>
<td>3</td>
</tr>
<tr>
<td>CEE 199</td>
<td>Undergraduate Research in Civil and Environmental Engineering</td>
<td>3-4</td>
</tr>
</tbody>
</table>

**Freshwater Environments Focus Area (37 units)**

**Required**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 70</td>
<td>Environmental Science and Technology</td>
<td>3</td>
</tr>
<tr>
<td>CEE 101B</td>
<td>Mechanics of Fluids</td>
<td>4</td>
</tr>
<tr>
<td>CEE 177</td>
<td>Aquatic Chemistry and Biology</td>
<td>4</td>
</tr>
<tr>
<td>CEE 166A</td>
<td>Watersheds and Wetlands</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>CEE 174A</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>EARTHSYS 238</td>
<td>3</td>
</tr>
</tbody>
</table>

**Electives**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 162E</td>
<td>Rivers, Streams, and Canals</td>
<td>3</td>
</tr>
<tr>
<td>CEE 165C</td>
<td>Water Resources Management</td>
<td>3</td>
</tr>
<tr>
<td>CEE 166A</td>
<td>Watersheds and Wetlands (if not counted as a req’d course)</td>
<td>4</td>
</tr>
<tr>
<td>CEE 166B</td>
<td>Floods and Droughts, Dams and Aqueducts</td>
<td>4</td>
</tr>
<tr>
<td>CEE 166D</td>
<td>Water Resources and Water Hazards Field Trips</td>
<td>2</td>
</tr>
<tr>
<td>CEE 230</td>
<td>Urban Development and Governance</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>EARTHSYS 238</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>CEE 174A</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOHOPK 150H</td>
<td>Ecological Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 163H</td>
<td>Oceanic Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>BIOHOPK 81</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>BIOHOPK 172H</td>
<td>5</td>
</tr>
<tr>
<td>or</td>
<td>EARTHSYS 116</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>OSPAUSTL 25</td>
<td>3</td>
</tr>
<tr>
<td>ESS 8</td>
<td>The Oceans: An Introduction to the Marine Environment</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>BIOHOPK 182H</td>
<td>4</td>
</tr>
</tbody>
</table>

**Coastal Environments Focus Area (37 units)**

**Required**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 70</td>
<td>Environmental Science and Technology</td>
<td>3</td>
</tr>
<tr>
<td>CEE 101B</td>
<td>Mechanics of Fluids</td>
<td>4</td>
</tr>
<tr>
<td>CEE 162F</td>
<td>Coastal Processes</td>
<td>3</td>
</tr>
<tr>
<td>CEE 175A</td>
<td>California Coast: Science, Policy, and Law</td>
<td>3-4</td>
</tr>
<tr>
<td>or</td>
<td>CEE 162I</td>
<td>3</td>
</tr>
</tbody>
</table>

**Electives**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 166A</td>
<td>Watersheds and Wetlands</td>
<td>4</td>
</tr>
<tr>
<td>CEE 166B</td>
<td>Floods and Droughts, Dams and Aqueducts</td>
<td>4</td>
</tr>
<tr>
<td>CEE 230</td>
<td>Urban Development and Governance</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>EARTHSYS 238</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>CEE 174B</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOHOPK 150H</td>
<td>Ecological Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BIOHOPK 163H</td>
<td>Oceanic Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIO 81</td>
<td>Introduction to Ecology</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>BIOHOPK 81</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>BIOHOPK 172H</td>
<td>5</td>
</tr>
<tr>
<td>or</td>
<td>EARTHSYS 116</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>OSPAUSTL 25</td>
<td>3</td>
</tr>
<tr>
<td>ESS 8</td>
<td>The Oceans: An Introduction to the Marine Environment</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>BIOHOPK 182H</td>
<td>4</td>
</tr>
</tbody>
</table>

**Capstone (1 class required)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 243</td>
<td>Infrastructure Project Development</td>
<td>3</td>
</tr>
<tr>
<td>CEE 179C</td>
<td>Environmental Engineering Design</td>
<td>5</td>
</tr>
<tr>
<td>CEE 224X</td>
<td>Disasters, Decisions, Development in Sustainable Urban Systems (CEE)</td>
<td>1-5</td>
</tr>
<tr>
<td>CEE 224Y</td>
<td>Sustainable Urban Systems Project</td>
<td>3-5</td>
</tr>
<tr>
<td>CEE 224Z</td>
<td>Sustainable Urban Systems Project</td>
<td>3-5</td>
</tr>
<tr>
<td>CEE 235</td>
<td>CapaCity Design Studio</td>
<td>5</td>
</tr>
<tr>
<td>CEE 199</td>
<td>Undergraduate Research in Civil and Environmental Engineering</td>
<td>3-4</td>
</tr>
</tbody>
</table>

**Freshwater Environments Focus Area (37 units)**

**Required**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 70</td>
<td>Environmental Science and Technology</td>
<td>3</td>
</tr>
<tr>
<td>CEE 101B</td>
<td>Mechanics of Fluids</td>
<td>4</td>
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<tr>
<td>CEE 162F</td>
<td>Coastal Processes</td>
<td>3</td>
</tr>
<tr>
<td>CEE 175A</td>
<td>California Coast: Science, Policy, and Law</td>
<td>3-4</td>
</tr>
<tr>
<td>or</td>
<td>CEE 162I</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS 224X</td>
<td>Disasters, Decisions, Development in Sustainable Urban Systems (CEE)</td>
<td>1-5</td>
</tr>
<tr>
<td>or</td>
<td>CEE 175C</td>
<td>5</td>
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**Electives**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARTHSYS 141</td>
<td>Remote Sensing of the Oceans</td>
<td>3-4</td>
</tr>
<tr>
<td>EARTHSYS 151</td>
<td>Biological Oceanography</td>
<td>3-4</td>
</tr>
<tr>
<td>or</td>
<td>EARTHSYS 152</td>
<td>3-4</td>
</tr>
</tbody>
</table>

**Capstone (1 class required)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 126</td>
<td>International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development</td>
<td>4-5</td>
</tr>
<tr>
<td>CEE 141A</td>
<td>Infrastructure Project Development</td>
<td>3</td>
</tr>
</tbody>
</table>
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 units minimum, see Basic Requirement 1 in right sidebar); science (17 units minimum, see Basic Requirement 2); a Technology in Society (one course from School of Engineering Approved Courses list; the course must be on the list the year it is taken; see Basic Requirement 4); at least two Engineering Fundamentals courses, see Basic Requirement 3 for a list of courses; a minimum of 34 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. Introductory Seminar courses (IntroSems) may not count toward the major. 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.

Qualified IDMEN students may pursue a Bachelor's degree with Honors (IDMEN-BSH) following the general guidelines outlined below, and consulting with advisers to set a topic and any further parameters regarding directed reading or research, special honors seminars, and the format of the honors work. The honors thesis, and any course work associated with the honors degree, is above and beyond the scope of the major itself and cannot be counted as part of the basic IDMEN-BS requirements.

Honors in Individually Designed Major in Engineering

1. The student must submit a letter applying for the honors option endorsed by the student's primary adviser and honors adviser; the letter should be submitted to the Office of Student Affairs in 135 Huang no later than mid-October of the senior year.
2. The IDMEN honors adviser may require course work beyond what is required for the BS without honors.
3. The student must maintain a GPA of at least 3.5.
4. The student must complete an honors thesis or project. The manner of evaluating the work will be set by the honors adviser and a second reader, one of whom must be a member of the Academic Council in the School of Engineering. The deadline to submit the thesis or project will be decided by the honors or program adviser but should be set by mid-May at latest.
5. The student must present the work in an appropriate forum, e.g., in the same session as honors theses are presented in the department of the adviser.
6. A copy of the signed (approved) thesis or project must be submitted to the Office of Student Affairs by the end of the second week of May.

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

Mathematics and Science

All required; see SoE Basic Requirements 1 and 2
CME 100 Vector Calculus for Engineers
or MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications
CME 103 Introduction to Matrix Methods
MS&E 120 Probabilistic Analysis
MS&E 121 Introduction to Stochastic Modeling
MS&E 125 Introduction to Applied Statistics

Select two of the following options:

<table>
<thead>
<tr>
<th>Units</th>
<th>Math, Science, or Statistics Elective from SoE approved lists.</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>CME 100 Vector Calculus for Engineers</td>
</tr>
<tr>
<td></td>
<td>CME 103 Introduction to Matrix Methods</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 120 Probabilistic Analysis</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 121 Introduction to Stochastic Modeling</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 125 Introduction to Applied Statistics</td>
</tr>
</tbody>
</table>

Engineering Depth

Core Courses (all six required)

<table>
<thead>
<tr>
<th>Units</th>
<th>CS 106B Programming Abstractions 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-27</td>
<td>or CS 106X Programming Abstractions (Accelerated)</td>
</tr>
<tr>
<td></td>
<td>ECON 50 Economic Analysis I</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 108 Senior Project (WIM)</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 111 Introduction to Optimization 4</td>
</tr>
<tr>
<td></td>
<td>or MS&amp;E 1111 Introduction to Optimization (Accelerated)</td>
</tr>
</tbody>
</table>

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

Finance and Decision Area

Students choosing F&D as their primary area must take at least two of ECON 51, MS&E 145 (or 245A), and MS&E 152 (or 252), as part of their 15 units.

Introductory (no prerequisites)

<table>
<thead>
<tr>
<th>Units</th>
<th>MS&amp;E 147 Finance and Society for non-MBAs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MS&amp;E 152 Introduction to Decision Analysis</td>
</tr>
</tbody>
</table>

Intermediate (has prerequisites and/or appropriate for juniors and seniors)

<table>
<thead>
<tr>
<th>Units</th>
<th>MS&amp;E 145 Introduction to Investment Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MS&amp;E 146 Corporate Financial Management</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 252 Decision Analysis I: Foundations of Decision Analysis</td>
</tr>
</tbody>
</table>

Advanced (intended primarily for graduate students, but may be taken by advanced undergraduates)

<table>
<thead>
<tr>
<th>Units</th>
<th>MS&amp;E 245A Investment Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MS&amp;E 245B Advanced Investment Science</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 246 Financial Risk Analytics</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 250A Engineering Risk Analysis</td>
</tr>
<tr>
<td></td>
<td>MS&amp;E 250B Project Course in Engineering Risk Analysis</td>
</tr>
</tbody>
</table>

Operations and Analytics Area

Students choosing O&A as their primary area may also include CS 161, CS 229, and STATS 202 in their selections

<table>
<thead>
<tr>
<th>Units</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MS&amp;E 112 Mathematical Programming and Combinatorial Optimization</td>
</tr>
</tbody>
</table>
MS&E 135  Networks
MS&E 213  Introduction to Optimization Theory
MS&E 223  Simulation
MS&E 226  “Small” Data: Prediction, Inference, Causality
MS&E 231  Introduction to Computational Social Science
MS&E 251  Introduction to Stochastic Control with Applications

Applications
MS&E 130  Information Networks and Services
MS&E 234  Data Privacy and Ethics
MS&E 235  Network Analytics
MS&E 260  Introduction to Operations Management
MS&E 263  Healthcare Operations Management
MS&E 267  Service Operations and the Design of Marketplaces
MS&E 330  Law, Order & Algorithms

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 184, and MS&E 185 as part of their 15 units

Introductory (no prerequisites)
ENGR 131  Ethical Issues in Engineering  4
MS&E 190  Methods and Models for Policy and Strategy Analysis
MS&E 193  Technology and National Security  4

Advanced (has prerequisites and/or appropriate for juniors and seniors)
ENGR 145  Technology Entrepreneurship
MS&E 175  Innovation, Creativity, and Change
or MS&E 177/Creativity Rules
MS&E 182  Leading Organizational Change
MS&E 183  Leadership in Action
MS&E 184  Future of Work: Issues in Organizational Learning and Design
MS&E 185  Global Work
MS&E 188  Organizing for Good
MS&E 243  Energy and Environmental Policy Analysis
MS&E 292  Health Policy Modeling
MS&E 294  Systems Modeling for Climate Policy Analysis
MS&E 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, and may not repeat material from any other requirement. AP/IB credit for Chemistry and Physics may be used.
2 Engineering fundamentals plus engineering depth must total a minimum of 60 units. Recommended engineering fundamentals are E25B, E25E, E40A, E40M, and E80.
3 Students may petition to place out of CS 106A Programming Methodology.
4 A course may only be counted towards one requirement; it may not be double-counted. For example, MS&E 193 may not count towards both TiS and towards the OTP depth area, and MS&E 111/ENGR 62 may not count towards both an engineering fundamental and towards the MS&E core depth.
5 All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.

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

Materials Science and Engineering (MSE/ 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

Mathematics
20 units minimum
Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 51</td>
<td>5</td>
</tr>
<tr>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications</td>
</tr>
<tr>
<td>CME 100/ENGR 154</td>
<td>Vector Calculus for Engineers</td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 52</td>
<td>5</td>
</tr>
<tr>
<td>MATH 52</td>
<td>Integral Calculus of Several Variables</td>
</tr>
<tr>
<td>CME 104/ENGR 155B</td>
<td>Linear Algebra and Partial Differential Equations for Engineers</td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 53</td>
<td>5</td>
</tr>
<tr>
<td>MATH 53</td>
<td>Ordinary Differential Equations with Linear Algebra</td>
</tr>
<tr>
<td>CME 102/ENGR 155A</td>
<td>Ordinary Differential Equations for Engineers</td>
</tr>
</tbody>
</table>

One additional course 1

Science
20 units minimum
Must include a full year (15 units) of calculus-based physics or chemistry, with one quarter of study (5 units) in the other subject. 2

Technology in Society
One course minimum 3

Engineering Fundamentals
Two courses minimum
Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

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, and may not repeat material from any other requirement. AP/IB credit for Chemistry and Physics may be used.
2 Engineering fundamentals plus engineering depth must total a minimum of 60 units. Recommended engineering fundamentals are E25B, E25E, E40A, E40M, and E80.
3 Students may petition to place out of CS 106A Programming Methodology.
# Materials Science & Engineering Depth

**Materials Science Fundamentals:** All of the following courses:  
- MATSCI 142 Quantum Mechanics of Nanoscale Materials  
- MATSCI 143 Materials Structure and Characterization  
- MATSCI 144 Thermodynamic Evaluation of Green Energy Technologies  
- MATSCI 145 Kinetics of Materials Synthesis

**Materials Science & Engineering Depth**  
- Two of the following courses:  
  - 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 158 Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life  
- 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

**Four laboratory courses for Sixteen units; Four units must be WIM**  
- MATSCI 151 Energy Materials Laboratory (WIM)  
- MATSCI 164 Electronic and Photonic Materials and Devices Laboratory (WIM)  
- MATSCI 160 Nanomaterials Laboratory  
- MATSCI 162 X-Ray Diffraction Laboratory  
- MATSCI 163 Mechanical Behavior Laboratory  
- MATSCI 165 Nanoscale Materials Physics Computation Laboratory

**Total Units:** 16

**Focus Area Options:** 13 units from one of the following Focus Area Options below. If the focus area contains only 12 units, but the combined unit total in major (SoE Fundamentals, MSE Fundamentals, MSE Depth and the Focus Area) is at 60 or more, it will be allowed and no petition is necessary.

See a list of approved Engineering Fundamentals Courses at ughb.stanford.edu. If two of ENGR 50, ENGR 50E or ENGR 50M are taken, one may be used for the Engineering Fundamentals requirement and the other for the Materials Science Fundamentals requirement.

The self-defined focus area option requires additional approval; program deviation forms for this option can be found on the MSE website (https://mse.stanford.edu/student-resources/forms/undergraduate).

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

## Focus Area Options (Four courses for a minimum of 13 units; select from one of the ten Focus Areas.)

### Bioengineering
- BIOE 80 Introduction to Bioengineering (Engineering Living Matter)  
- BIOE 220 Introduction to Imaging and Image-based Human Anatomy  
- BIOE 260 Tissue Engineering  
- BIOE 281 Biomechanics of Movement  
- BIOE 381 Orthopaedic Bioengineering  
- MATSCI 158 Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life  
- MATSCI 190 Organic and Biological Materials  
- MATSCI 380 Nano-Biotechnology  
- MATSCI 381 Biomaterials in Regenerative Medicine  
- MATSCI 382 Biochips and Medical Imaging

### Chemical Engineering
- CHEM 171 Physical Chemistry I  
- CHEMENG 130 Separation Processes  
- CHEMENG 140 Micro and Nanoscale Fabrication Engineering  
- CHEMENG 150 Biochemical Engineering  
- MATSCI 158 Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life  

### Chemistry
- 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
- 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 Devices for Energy and Electronics  
- EE 134 Introduction to Photonics

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1. See a list of approved math courses at ughb.stanford.edu. AP/IB Credit may also be used to meet the 20 units minimum, but cannot replace the three required courses.
2. See a list of approved science courses at ughb.stanford.edu. AP/IB Credit may also be used to meet the 20 units minimum in some cases; see the AP chart in the Bulletin or check with the School of Engineering in 135 Huang Engineering Center.
3. See a list of approved Technology in Society courses at ughb.stanford.edu. Course chosen must be on the approved list the year taken.
4. See a list of approved Engineering Fundamentals Courses at ughb.stanford.edu. If two of ENGR 50, ENGR 50E or ENGR 50M are taken, one may be used for the Engineering Fundamentals requirement and the other for the Materials Science Fundamentals requirement.
5. Focus Area Options: 13 units from one of the following Focus Area Options below. If the focus area contains only 12 units, but the combined unit total in major (SoE Fundamentals, MSE Fundamentals, MSE Depth and the Focus Area) is at 60 or more, it will be allowed and no petition is necessary.
6. The self-defined focus area option requires additional approval; program deviation forms for this option can be found on the MSE website (https://mse.stanford.edu/student-resources/forms/undergraduate).
7. A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.
### School of Engineering

#### Mechanical Behavior & Design
- EE 142: Engineering Electromagnetics (Formerly EE 141)
- EE 155: Green Electronics
- ME 210: Introduction to Mechatronics
- MATSCI 343: Organic Semiconductors for Electronics and Photonics
- MATSCI 346: Nanophotonics

#### Energy Technology
- EE 293B: Fundamentals of Energy Processes
- EE 155: Green Electronics
- CEE 107A: Understanding Energy
- 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
- ME 262: Physics of Wind Energy

#### Materials Characterization Techniques
- 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
- CHEMENG 345: Fundamentals and Applications of Spectroscopy
- BIO 232: Advanced Imaging Lab in Biophysics
- APPPHYS 201: Electrons and Photons (PHOTON 201)

#### Mechanical Behavior & Design
- AA 240: Analysis of Structures
- AA 256: Mechanics of Composites
- MATSCI 198: Mechanical Properties of Materials
- MATSCI 241: Mechanical Behavior of Nanomaterials
- 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

#### Nanoscience
- ENGR 240: Introduction to Micro and Nano Electromechanical Systems
- MATSCI 241: Mechanical Behavior of Nanomaterials
- MATSCI 316: Nanoscale Science, Engineering, and Technology
- MATSCI 320: Nanocharacterization of Materials
- MATSCI 346: Nanophotonics
- MATSCI 347: Magnetic materials in nanotechnology, sensing, and energy
- MATSCI 380: Nano-Biotechnology

#### Physics
- 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
- Petition for a self-defined cohesive program.

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

### Honors Program

The Materials Science and Engineering honors program offers an opportunity for undergraduate Materials Science and Engineering majors with a GPA of 3.5 or higher to pursue independent research at an advanced level, supported by a faculty advisor and graduate student mentors. The main requirements are as follows:

1. Application to the honors program (must be pre-approved by faculty advisor)
2. Enrollment in MATSCI 150 and participation in an independent research project over three sequential full quarters
3. Completion of a faculty-approved thesis
4. Participation in either the yearly Materials Science and Engineering Research Symposium OR an alternate, approved public oral/poster presentation

Since this requires three full quarters of research in addition to a final written thesis and presentation following completion of the work, students must apply to the program no less than four quarters prior to their planned graduation date. Materials Science and Engineering majors pursuing a typical four-year graduation timeline should meet with student services no later than the Winter quarter of their junior year to receive information on the application process.

All requirements for the honors program are in addition to the normal undergraduate program requirements.

#### To apply to the MATSCI Honors program:
- Have an overall GPA of 3.5 or higher (as calculated on the unofficial transcript) prior to application.
- Seek out a MATSCI faculty advisor and agree on a proposed research topic. Primary honors advisor must be a member of the School of Engineering academic council.
- Compose a brief (less than 1 page) summary of proposed research, including a proposed title, and submit along with unofficial transcript and signed faculty endorsement.
- Submit application at least four quarters prior to planned graduation.

#### To complete the MATSCI Honors program:
- Overall GPA of 3.5 or higher (as calculated on the unofficial transcript) at graduation
- Complete at least three quarters of research with a minimum of 9 units of MATSCI 150 for a letter grade (students may petition out of unit requirement with faculty advisor approval). All quarters must focus on the same topic. Maintain the same faculty advisor throughout, if possible.
- Present either a poster or oral presentation of thesis work in the Materials Science and Engineering Research Symposium held during Spring Quarter or, at the faculty advisor’s discretion, in a comparable public event.
- Submit final drafts of an Honors Thesis to Dr. Ryan Brock and to the faculty advisor at least one quarter prior to graduation. Both must approve the thesis by completing a Signature Page and returning it to student services.
- Submit to MATSCI student services one copy of the honors thesis in electronic form at the same time as the final hard copy. Submit one copy of the thesis, with the signature page indicating approval of both
 readers (primary advisor and Dr. Brock), to the School of Engineering’s Office of Student Affairs in 135 Huang.

**Mechanical Engineering (ME)**

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

**Mission of the Undergraduate Program in Mechanical Engineering**

The mission of the undergraduate program in Mechanical Engineering is to provide students with a balance of theoretical and practical experiences that enable them to address a variety of societal needs. The curriculum encompasses elements from a wide range of disciplines built around the themes of biomechanics, 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 science and technology, propulsion, sensing and control, nano- and microelectromechanical systems, biomechanical engineering, energy mechatronics, computational simulation, solid and fluid dynamics, design, energy, and multiscale engineering. Course work may include built around the themes of biomedicine, computational engineering, the technologies in Society that enable them to address a variety of societal needs.

**Core Requirements**

**Mathematics**

24 units minimum; see Basic Requirement 1

- CME 102/ ENGR 155A
- or MATH 53 Ordinary Differential Equations for Engineers
- Select one of the following:
  - CME 106/ ENGR 155C Introduction to Probability and Statistics for Engineers
  - STATS 110 Statistical Methods in Engineering and the Physical Sciences
  - STATS 116 Theory of Probability

Plus additional courses to total min. 24

**Science**

20 units minimum; see Basic Requirement 2

- CHEM 31X Chemical Principles Accelerated

Plus additional required courses

**Technology in Society**

One course required; TIS courses should be selected from AA 252, BIOE 131, CS 181, ENGR 131 or ME 267

**Engineering Fundamentals**

Two courses minimum; see Basic Requirement 3

- ENGR 14 Intro to Solid Mechanics
- ENGR 70A Programming Methodology (same as CS 106A)

**Engineering Core**

Minimum of 68 Engineering Science and Design ABET units; see Basic Requirement 5

- ME 1 Introduction to Mechanical Engineering
- ME 102 Foundations of Product Realization
- ME 103 Product Realization: Design and Making
- ME 112 Mechanical Systems Design
- ME 123 Computational Engineering
- ME 131A Heat Transfer

**Core Concentrations and Concentration Electives**

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

**Dynamic Systems and Controls Concentration**

ME 161 Dynamic Systems, Vibrations and Control
- ENGR 105 Feedback Control Design
- Pick one of:
  - ME 227 Vehicle Dynamics and Control
  - ME 327 Design and Control of Haptic Systems

**Materials and Structures Electives**

ME 149 Mechanical Measurements
- ME 151 Introduction to Computational Mechanics (offered WIN 18-19; more information to come)
- ME 152 Material Behaviors and Failure Prediction

**Dynamic Systems and Controls Electives**

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

**Materials and Structures Concentration**

ME 149 Mechanical Measurements
- ME 151 Introduction to Computational Mechanics (offered WIN 18-19; more information to come)
- ME 152 Material Behaviors and Failure Prediction

**Materials and Structures Electives**

ME 234 Introduction to Neuromechanics
- ME 241 Mechanical Behavior of Nanomaterials
- ME 281 Biomechanics of Movement
- ME 283 Introduction to Biomechanics and Mechanobiology
- ME 287 Mechanics of Biological Tissues
- ME 331A Advanced Dynamics & Computation
- ME 335A Finite Element Analysis
- ME 339 Continuum Mechanics
- ME 339 Introduction to parallel computing using MPI, openMP, and CUDA
- ME 345 Fatigue Design and Analysis
- ME 348 Experimental Stress Analysis

**Manufacturing and Product Realization Concentration**

ME 127 Design for Additive Manufacturing
- ME 128 Computer-Aided Product Realization
- ME 129 (Offered AY 19-20)

**Manufacturing and Product Realization Electives**

ENGR 110 Perspectives in Assistive Technology (ENGR 110)
BSME 1.0 Student Notes

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

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

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

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.

Requirements

<table>
<thead>
<tr>
<th>Mathematics and Science</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics 1,2</td>
<td>20 units minimum</td>
</tr>
<tr>
<td>Science 2</td>
<td>16 units minimum</td>
</tr>
<tr>
<td>16 units minimum : Minimum of 9 units of SoE approved science and 8 units of Behavioral Science 23</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 41 Mechanics</td>
<td>4-5</td>
</tr>
<tr>
<td>or PHYSICS 41 Mechanics, Concepts, Calculations, and Context</td>
<td></td>
</tr>
<tr>
<td>PSYCH 1 Introduction to Psychology</td>
<td>5</td>
</tr>
<tr>
<td>PSYCH or HUMBIO elective 1</td>
<td>3-5</td>
</tr>
<tr>
<td>Technology in Society</td>
<td>3-5 units</td>
</tr>
</tbody>
</table>

One course required; must be on the SoE approved TiS courses list at <ughb.stanford.edu> the year it is taken.

Engineering Fundamentals

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>ENGR 70A Programming Methodology</td>
</tr>
<tr>
<td>ENGR 40M or ENGR 40A Introductory Electronics</td>
</tr>
</tbody>
</table>

Product Design Engineering Depth

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>ENGR 14 Intro to Solid Mechanics</td>
</tr>
<tr>
<td>ME 80 Mechanics of Materials</td>
</tr>
</tbody>
</table>

1 Math and science must total 45 units.
2 ME 112 fulfills the WIM requirement.
3 ME 170A and ME 170B are a 2-quarter Capstone Design Sequence and must be taken in consecutive quarters.
4 A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.
5 ME 129 will be offered Winter Quarter of AY 2019-20. Product realization students should take one of their concentration electives, or ME 219, in AY 2018-19.

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu).
that reduces the total unit requirement for each major. Intellectual traditions of two Stanford departments—it does so in a way and integrated capstone experience. The Joint Major not only blends the of the two fields through a cohesive, transdisciplinary course of study.

Because the JMP is new and experimental, changes to procedures may periodically. Students should plan their overseas quarter to take quarter overseas or at one of the BOSP campuses in New York or Washington DC. Students should plan their overseas quarter to take place in sophomore year, or Spring Quarter of the junior year only. If the student elects to go overseas junior year, the total depth units are reduced by 4; 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 (https://stanford.box.com/change-UG-program). The Major-Minor and Multiple Major Course Approval Form (https://stanford.box.com/MajMin-MultMaj) 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 (https://stanford.box.com/change-UG-program). Students may also consult the Student Services Center (http://studentservicescenter.stanford.edu) for 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 core major and minor requirements.

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. If any core classes (aside from ENGR 21; see footnote) are part of student’s major or other degree program, the Aero/Astro adviser can help select substitute courses to fulfill the Aero/Astro minor requirements; no double counting allowed. All courses taken for the minor must be taken for a letter grade if that option is offered by the instructor. Minimum GPA for all minor courses combined is 2.0.

The following core courses fulfill the minor requirements:

<table>
<thead>
<tr>
<th>AA Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Core Units, 24 Total Program Units</td>
</tr>
<tr>
<td>ENGR 21  Engineering of Systems 2</td>
</tr>
<tr>
<td>AA 100  Introduction to Aeronautics and Astronautics</td>
</tr>
<tr>
<td>AA 131  Space Flight</td>
</tr>
<tr>
<td>AA 141  Atmospheric Flight</td>
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<table>
<thead>
<tr>
<th>AA Electives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choose 4 courses</td>
</tr>
<tr>
<td>AA 101  Introduction to Aero Fluid Mechanics 1</td>
</tr>
<tr>
<td>AA 102  Introduction to Applied Aerodynamics</td>
</tr>
<tr>
<td>AA 103  Air and Space Propulsion</td>
</tr>
<tr>
<td>AA 111  Introduction to Aerospace Computational Engineering 1</td>
</tr>
<tr>
<td>AA 135  Introduction to Space Policy 1</td>
</tr>
<tr>
<td>AA 151  Lightweight Structures</td>
</tr>
<tr>
<td>AA 156  Mechanics of Composite Materials</td>
</tr>
<tr>
<td>AA 171  Autonomous Systems 1</td>
</tr>
<tr>
<td>AA 173  Flight Mechanics and Controls 1</td>
</tr>
<tr>
<td>AA 175  Embedded Programming 1</td>
</tr>
<tr>
<td>AA 272C  Global Positioning Systems</td>
</tr>
<tr>
<td>AA 279A  Space Mechanics</td>
</tr>
<tr>
<td>ENGR 105  Feedback Control Design</td>
</tr>
</tbody>
</table>

1  This course will be offered in the future. Please see our website for future course offerings (https://aa.stanford.edu/academics/undergraduate-program). For courses yet not offered please contact the Aero/Astro Student Services Office (https://aa.stanford.edu/academics/student-services-office) for a list of approved replacement courses.

2  ENGR 21 is waived as minor requirement if already taken as part of the major program.

Chemical Engineering Minor
The following core courses fulfill the minor requirements:

| ENGR 20  Introduction to Chemical Engineering | 4 |
| 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 | 4 |
| CHEMENG 180  Chemical Engineering Plant Design | 4 |

Select one of the following:

| CHEMENG 140  Micro and Nanoscale Fabrication Engineering | 3 |
| CHEMENG 142  Basic Principles of Heterogeneous Catalysis with Applications in Energy Transformations | 4 |
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 19 Calculus (or MATH 20 Calculus or MATH 21 Calculus); however, many courses of interest require PHYSICS 41 Mechanics and/or MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications as prerequisites. The minimum prerequisite for a Civil Engineering minor focusing on architectural design is MATH 19 Calculus (or MATH 20 Calculus or MATH 21 Calculus). 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) 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 (or CME 100).

Electives (choose two courses from different areas):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 124</td>
<td>From Languages to Information</td>
<td>4</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>4</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
</tbody>
</table>

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:

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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 19 Calculus (or MATH 20 Calculus or MATH 21 Calculus); additionally, many courses of interest require PHYSICS 41 Mechanics and/or MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications 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://web.stanford.edu/group/ughb/cgi-bin/handbook/index.php/Handbooks).

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 (https://cee.stanford.edu/academics/undergraduate-programs/minor).

Professor Nicholas Ouellette (nto@stanford.edu) is the CEE undergraduate minor adviser in Environmental Systems Engineering. Students must consult with Professor Ouellette (https://cee.stanford.edu/people/nicholas-t-ouellette) in developing their minor program, and obtain approval of the finalized study list from him.

Management Science and Engineering (MS&E) Minor

The following courses are required to fulfill the minor requirements:

<table>
<thead>
<tr>
<th>Background requirements (two courses; letter-graded or CR/NC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 100 Vector Calculus for Engineers</td>
</tr>
<tr>
<td>or MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications</td>
</tr>
<tr>
<td>CS 106A Programming Methodology</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minor requirements (seven courses; all letter-graded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS&amp;E 111 Introduction to Optimization</td>
</tr>
<tr>
<td>or MS&amp;E 111X Introduction to Optimization (Accelerated)</td>
</tr>
<tr>
<td>MS&amp;E 120 Probabilistic Analysis</td>
</tr>
<tr>
<td>MS&amp;E 121 Introduction to Stochastic Modeling</td>
</tr>
<tr>
<td>MS&amp;E 125 Introduction to Applied Statistics</td>
</tr>
<tr>
<td>MS&amp;E 180 Organizations: Theory and Management</td>
</tr>
<tr>
<td>Electives (select any two 100- or 200-level MS&amp;E courses)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>5</td>
</tr>
<tr>
<td>3-4</td>
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<tr>
<td>4</td>
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<td>4</td>
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<td>5</td>
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<table>
<thead>
<tr>
<th>Recommended courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 50 Economic Analysis I</td>
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</table>

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>5</td>
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</tbody>
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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:

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>24</td>
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</table>

<table>
<thead>
<tr>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 50 Introduction to Materials Science, Nanotechnology Emphasis</td>
</tr>
<tr>
<td>ENGR 50E Introduction to Materials Science, Energy Technologies</td>
</tr>
<tr>
<td>ENGR 50M Introduction to Materials Science, Biomaterials Emphasis</td>
</tr>
<tr>
<td>MATSCI 142 Quantum Mechanics of Nanoscale Materials</td>
</tr>
<tr>
<td>MATSCI 143 Materials Structure and Characterization</td>
</tr>
<tr>
<td>MATSCI 144 Thermodynamic Evaluation of Green Energy Technologies</td>
</tr>
<tr>
<td>MATSCI 145 Kinetics of Materials Synthesis</td>
</tr>
<tr>
<td>MATSCI 151 Microstructure and Mechanical Properties</td>
</tr>
<tr>
<td>MATSCI 152 Electronic Materials Engineering</td>
</tr>
<tr>
<td>MATSCI 156 Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution</td>
</tr>
<tr>
<td>MATSCI 158 Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life</td>
</tr>
<tr>
<td>MATSCI 160 Nanomaterials Laboratory</td>
</tr>
<tr>
<td>MATSCI 161 Energy Materials Laboratory</td>
</tr>
<tr>
<td>MATSCI 162 X-Ray Diffraction Laboratory</td>
</tr>
<tr>
<td>MATSCI 163 Mechanical Behavior Laboratory</td>
</tr>
<tr>
<td>MATSCI 164 Electronic and Photonic Materials and Devices Laboratory</td>
</tr>
<tr>
<td>MATSCI 165 Nanoscale Materials Physics Computation Laboratory</td>
</tr>
<tr>
<td>MATSCI 190 Organic and Biological Materials</td>
</tr>
<tr>
<td>MATSCI 192 Materials Chemistry</td>
</tr>
<tr>
<td>MATSCI 193 Atomic Arrangements in Solids</td>
</tr>
<tr>
<td>MATSCI 194 Thermodynamics and Phase Equilibria</td>
</tr>
<tr>
<td>MATSCI 195 Waves and Diffraction in Solids</td>
</tr>
<tr>
<td>MATSCI 196 Defects in Crystalline Solids</td>
</tr>
<tr>
<td>MATSCI 197 Rate Processes in Materials</td>
</tr>
<tr>
<td>MATSCI 198 Mechanical Properties of Materials</td>
</tr>
<tr>
<td>MATSCI 199 Electronic and Optical Properties of Solids</td>
</tr>
</tbody>
</table>

Total Units: 28

Mechanical Engineering (ME) Minor

The following courses fulfill the minor requirements:
**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.

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.) 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. The actual transfer is accomplished through the Graduate Authorization Petition process.

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.

Departments may have additional requirements or expectations for programs of study which they would recommend for this degree; further information may be found in departmental listings or handbooks.

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 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) 204-3984; fax (650) 725-2868; or email scpd-customerservice@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" 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" section of the Bulletin. Further information is found in departmental listings.

Dean: Jennifer Widom

Senior Associate Deans: Stacey Bent (Faculty and Academic Affairs), Laura L. Breyfogle (External Relations), Scott Calvert (Administration), Thomas Kenny (Student Affairs)

Associate Dean: Kirsti Copeland (Student Affairs)

Assistant Dean: Sally Gressens (Graduate Student Affairs)

Faculty Teaching General Engineering Courses

Professors: Juan Alonso, Mark Cappelli, Ashish Goel, Chaitan Khosla, Chris Gerdes, Mark Horowitz, Roger Howe, Ellen Kuhl, Allison Okamura, Peter Pinsky, Jim Plummer, Stephen M. Rock, Bernard Roth, Sheri Sheppard, Robert Sinclair, Simon Wong, Yinyu Ye

Associate Professors: Eric Darve, Chuck Eesley, Sarah Heilshorn, W. Matthias Ihme, Michael Lepech, Jan Liphardt, Nick Melosh, Amin Saberi, Thomas Jaramillo, Tina Seelig

Assistant Professors: Sindy Tang

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

Senior Lecturers: Vadim Khayms

Lecturers: Jeff Epstein, Christopher Gregg, Kelly Harrison, David Jaffe, Victoria Kirst, Royal Kopperud, Hung Le, Cynthia Bailey Lee, Mary McDevitt, Chris Piech, Marty Stepp, Matt Vassar

Professor of the Practice: Tina Seelig

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).

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSPBER 40M</td>
<td>An Intro to Making: What is EE</td>
<td>5</td>
</tr>
<tr>
<td>OSPBER 50M</td>
<td>Introductory Science of Materials</td>
<td>4</td>
</tr>
<tr>
<td>OSPFLOR 50M</td>
<td>Introductory Science of Materials</td>
<td>4</td>
</tr>
<tr>
<td>OSPKYOTO 40M</td>
<td>An Intro to Making: What is EE</td>
<td>5</td>
</tr>
<tr>
<td>OSPPARIS 40M</td>
<td>An Intro to Making: What is EE</td>
<td>5</td>
</tr>
<tr>
<td>OSPPARIS 50M</td>
<td>Introductory Science of Materials</td>
<td>4</td>
</tr>
</tbody>
</table>