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://ughp.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.
Curricula for majors are offered by the departments of:

- 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
- Microrheology
- Molecular Assemblies
- Nanoscience and Technology
- Newtonian and Non-Newtonian Fluid Mechanics
- Polymer Physics
- Protein Biotechnology
- Renewable Fuels
- Semiconductor Processing
- Soft Materials Science
- Solar Utilization
- Surface and Interface Science
- Transport Mechanics

Civil and Environmental Engineering
- Atmosphere/Energy
- 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
• Stochastic Systems
• Strategy

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

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

Bachelor of Science in the School of Engineering

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/energysourcesengineering)" 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 Code</th>
<th>Course Name</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>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</td>
</tr>
<tr>
<td>ENGR 50M</td>
<td>Introduction to Materials Science, Biomaterials Emphasis</td>
<td>1</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>1</td>
</tr>
<tr>
<td>ENGR 70X/CS 106X</td>
<td>Programming Abstractions (Accelerated)</td>
<td>1</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 68 units of Engineering Fundamentals and Engineering Depth appropriate to the student's field of study. In most cases, students meet this requirement by completing the major program core and elective requirements. A student may need to take additional courses in Depth in order to fulfill the minimum requirement. Appropriate courses assigned to fulfill each major's program are listed online at http://ughb.stanford.edu 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://bsp.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</td>
<td>Calculus (required)</td>
</tr>
<tr>
<td>MATH 20</td>
<td>Calculus (required)</td>
</tr>
<tr>
<td>MATH 21</td>
<td>Calculus (required)</td>
</tr>
<tr>
<td>CME 100/ENGR 154</td>
<td>Vector Calculus for Engineers (required)</td>
</tr>
<tr>
<td>or MATH 51</td>
<td>Linear Algebra and Differential Calculus of Several Variables</td>
</tr>
<tr>
<td>CME 102/ENGR 155A</td>
<td>Ordinary Differential Equations for Engineers (required)</td>
</tr>
<tr>
<td>or MATH 53</td>
<td>Ordinary Differential Equations with Linear Algebra</td>
</tr>
<tr>
<td>CME 106/ENGR 155C</td>
<td>Introduction to Probability and Statistics for Engineers (required)</td>
</tr>
<tr>
<td>or STATS 110</td>
<td>Statistical Methods in Engineering and the Physical Sciences</td>
</tr>
<tr>
<td>or STATS 116</td>
<td>Theory of Probability</td>
</tr>
<tr>
<td>or CS 109</td>
<td>Introduction to Probability for Computer Scientists</td>
</tr>
<tr>
<td>CME 104</td>
<td>Linear Algebra and Partial Differential Equations for Engineers (recommended)</td>
</tr>
<tr>
<td>or MATH 52</td>
<td>Integral Calculus of Several Variables</td>
</tr>
<tr>
<td>CME 108</td>
<td>Introduction to Scientific Computing (recommended)</td>
</tr>
</tbody>
</table>

**Science**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 41</td>
<td>Mechanics (required)</td>
</tr>
<tr>
<td>or PHYSICS 41B</td>
<td>Mechanics, Concepts, Calculations, and Context</td>
</tr>
<tr>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism (required)</td>
</tr>
<tr>
<td>PHYSICS 45</td>
<td>Light and Heat (required)</td>
</tr>
<tr>
<td>CHEM 31X</td>
<td>Chemical Principles Accelerated (or CHEM 31A and CHEM 31B, or AP Chemistry) (required)</td>
</tr>
<tr>
<td>ENGR 80</td>
<td>Introduction to Bioengineering (Engineering Living Matter) (recommended)</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</td>
<td>Ethical Issues in Engineering (recommended)</td>
</tr>
<tr>
<td>AA 252</td>
<td>Techniques of Failure Analysis (recommended)</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</td>
<td>Engineering of Systems (required)</td>
</tr>
<tr>
<td>ENGR 70A/CS 106A</td>
<td>Programming Methodology (required)</td>
</tr>
<tr>
<td>ENGR 10</td>
<td>Introduction to Engineering Analysis (recommended)</td>
</tr>
<tr>
<td>ENGR 40M</td>
<td>An Intro to Making: What is EE (recommended)</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**

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

**Aero/Astro Focus Electives**

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

**Aero/Astro Capstone Requirement**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 123A</td>
<td>Air Capstone I, satisfies the Writing in the Major requirement, (WIM)</td>
</tr>
<tr>
<td>AA 123B</td>
<td>Air Capstone II</td>
</tr>
<tr>
<td>AA 124A</td>
<td>Space Capstone I, satisfies the Writing in Major requirement, (WIM)</td>
</tr>
<tr>
<td>AA 124B</td>
<td>Space Capstone II</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 website 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 or PHYSICS 23E-Electricity and Magnetism |   |

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.

Engineering Fundamentals

Two courses minimum, see Basic Requirement 3

| ENGR 14 Intro to Solid Mechanics | 6-8   |

AD Depth Core

| CEE 31 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 | 5     |
| CEE 137B Advanced Architecture Studio | 6     |
| ARTHIST 3 Introduction to World Architecture | 5     |

Depth Options

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 |   |
Architectural Design Honors Program

The AD honors program offers eligible students the opportunity to engage in guided original research, or project design, over the course of an academic year. For interested students the following outlines the process:

1. The student must submit a letter applying for the honors option endorsed by the student’s primary adviser and honors adviser and submitted to the student services office in CEE. Applications must be received in the fourth quarter prior to graduation. It is strongly suggested that students meet with the Architectural Design Program Director well in advance of submitting an application.

2. The student must maintain a GPA of at least 3.5.

3. The student must complete an honors thesis or project. The timing and deadlines are to be decided by the program or honors adviser. At least one member of the evaluation committee must be a member of the Academic Council in the School of Engineering.

4. 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 advisor. All honors programs require some public presentation of the thesis or project.

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

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): 23

<table>
<thead>
<tr>
<th>Units</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Group A: Ordinary Differential Equations with Linear Algebra</td>
</tr>
<tr>
<td>1</td>
<td>Group B: Introduction to Probability and Statistics for Engineers</td>
</tr>
<tr>
<td>1</td>
<td>STAT 101 Data Science 101</td>
</tr>
<tr>
<td>1</td>
<td>STAT 110 Statistical Methods in Engineering and the Physical Sciences</td>
</tr>
</tbody>
</table>

Science (20 units minimum, including all of the following):

<table>
<thead>
<tr>
<th>Units</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>PHYSICS 41 Mechanics</td>
</tr>
<tr>
<td>1</td>
<td>OR PHYSICS 45ght and Heat</td>
</tr>
<tr>
<td>1</td>
<td>CHEM 31B Chemical Principles II</td>
</tr>
<tr>
<td>1</td>
<td>OR CHEM 31L Chemical Principles Accelerated</td>
</tr>
<tr>
<td>1</td>
<td>CEE 70 Environmental Science and Technology</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>
<th>Writing in the Major (WIM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIOE 131 Ethics in Bioengineering</td>
</tr>
<tr>
<td>1</td>
<td>COMM 120W Digital Media in Society</td>
</tr>
<tr>
<td>OR</td>
<td>CEE 100 Managing Sustainable Building Projects</td>
</tr>
</tbody>
</table>
EARTHSYS 200 Environmental Communication in Action: The SAGE Project

Fundamentals and Depth: At least 40 units total must be from the School of Engineering

**Engineering Fundamentals**

Two courses minimum (recommend 3), including at least one of the following:
- ENGR 25E Energy: Chemical Transformations for Production, Storage, and Use
- ENGR 50E Introduction to Materials Science, Energy Emphasis

Plus at least one of the following:
- ENGR 10 Introduction to Engineering Analysis
- ENGR 70A Programming Methodology

A third Fundamental is optional but recommended (3-4 units)

**Engineering Depth**

Required: 6-8 units. Introductory seminars may not count toward Engineering Depth.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 64</td>
<td>Air Pollution and Global Warming: History, Science, and Solutions (cannot also fulfill science requirement)</td>
<td>3</td>
</tr>
<tr>
<td>CEE 107A</td>
<td>Understanding Energy</td>
<td>3-5</td>
</tr>
<tr>
<td>or CEE 107S</td>
<td>Energy Resources: Fuels and Tools</td>
<td>36</td>
</tr>
<tr>
<td>34-36 units from the following with at least four courses from each group; at least 40 of the units in ENGR Fundamentals and Depth must be from the School of Engineering:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Group A: Atmosphere**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 100</td>
<td>Introduction to Aeronautics and Astronautics</td>
<td></td>
</tr>
<tr>
<td>CEE 63</td>
<td>Weather and Storms</td>
<td></td>
</tr>
<tr>
<td>CEE 101B</td>
<td>Mechanics of Fluids</td>
<td></td>
</tr>
<tr>
<td>or ME 70</td>
<td>Introductory Fluids Engineering</td>
<td></td>
</tr>
<tr>
<td>CEE 161C</td>
<td>Natural Ventilation of Buildings</td>
<td></td>
</tr>
<tr>
<td>CEE 161I</td>
<td>Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation</td>
<td></td>
</tr>
<tr>
<td>CEE 162I</td>
<td>Atmosphere, Ocean, and Climate Dynamics: The Ocean Circulation</td>
<td></td>
</tr>
<tr>
<td>CEE 172</td>
<td>Air Quality Management</td>
<td></td>
</tr>
<tr>
<td>CEE 178</td>
<td>Introduction to Human Exposure Analysis</td>
<td></td>
</tr>
<tr>
<td>EARTHSYS 111</td>
<td>Biology and Global Change</td>
<td>5</td>
</tr>
<tr>
<td>or EARTHSYS 142</td>
<td>Remote Sensing of Land</td>
<td>5</td>
</tr>
<tr>
<td>EARTHSYS 188</td>
<td>Social and Environmental Tradeoffs in Climate Decision-Making</td>
<td>5</td>
</tr>
<tr>
<td>ME 131B</td>
<td>Fluid Mechanics: Compressible Flow and Turbomachinery</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 199</td>
<td>The Physics of Energy and Climate Change</td>
<td>5</td>
</tr>
<tr>
<td>EARTH 2</td>
<td>Climate and Society</td>
<td>5</td>
</tr>
<tr>
<td>EARTHSYS 196</td>
<td>Implementing Climate Solutions at Scale</td>
<td>5</td>
</tr>
</tbody>
</table>

**Group B: Energy**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 156</td>
<td>Building Systems</td>
<td></td>
</tr>
<tr>
<td>CEE 173S</td>
<td>Electricity Economics</td>
<td></td>
</tr>
<tr>
<td>CEE 176A</td>
<td>Energy Efficient Buildings</td>
<td></td>
</tr>
<tr>
<td>CEE 176B</td>
<td>100% Clean, Renewable Energy and Storage for Everything</td>
<td></td>
</tr>
<tr>
<td>CEE 177S</td>
<td>Design for a Sustainable World</td>
<td></td>
</tr>
<tr>
<td>EARTHSYS 101</td>
<td>Energy and the Environment</td>
<td>5</td>
</tr>
<tr>
<td>EARTHSYS 102</td>
<td>Fundamentals of Renewable Power</td>
<td>5</td>
</tr>
<tr>
<td>ENERGY 104</td>
<td>Sustainable Energy for 9 Billion</td>
<td></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). The application must include an unofficial Stanford transcript. Applications must be received in the fourth quarter prior to graduation. It is strongly suggested that prospective honors students meet with the proposed honors adviser well in advance of submitting an application.
2. Students must maintain a GPA of at least 3.5.
3. Students must complete an honors thesis or project over a period of three quarters. The typical length of the written report is 15-20 pages. The deadline for submission of the report is to be decided by the honors adviser, but should be no later than the end of the third week in May.
4. The report must be read and evaluated by the student’s honors adviser and one other reader. It is the student’s responsibility to find and obtain both the adviser and the reader. At least one of the two must be a member of the Academic Council in the School of Engineering.
5. Students must present the completed work in an appropriate forum, e.g. in the same session as honors theses are presented in the department of the adviser. All honors programs require some public presentation of the thesis or project.
6. Students may take up to 10 units of CEE 199H Undergraduate Honors Thesis(optional). However, students must take ENGR 202S Directed Writing Projects or its equivalent (required). Units for the writing class are beyond those required for the A/E major.
Bioengineering (BIOE)

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

Mission of the Undergraduate Program in Bioengineering

The Stanford Bioengineering 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**
  - Vector Calculus for Engineers
  - and Ordinary Differential Equations for Engineers (Recommended)
  - 10 units
- **MATH 51**
  - Linear Algebra and Differential Calculus of Several Variables
  - and Ordinary Differential Equations with Linear Algebra
  - 10 units

Select one of the following:

- **CME 106**
  - Introduction to Probability and Statistics for Engineers (Recommended)
  - 4-5 units
- or **STATS 110**
  - Statistical Methods in Engineering and the Physical Sciences
  - 3-5 units
- or **STATS 141**
  - Biostatistics
  - 3 units

Science

26 units minimum ²

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

Technology in Society

- **BIOE 131**
  - Ethics in Bioengineering (WIM)
  - 3 units

Engineering Fundamentals

- **BIOE 80**
  - Introduction to Bioengineering (Engineering Living Matter)
  - 4 units

CS 106A

- Programming Methodology (or CS 106B or CS 106X)
- 5 units

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

Bioengineering Core

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

Bioengineering Depth Electives

- Four courses, minimum 12 units:

  - **BIOE 115**
    - Computational Modeling of Microbial Communities
  - **BIOE 122**
    - Biosecurity and Bioterrorism Response
  - **BIOE 201C**
    - Diagnostic Devices Lab
  - or **BIOE 51**
    - Anatomy for Bioengineers
  - **BIOE 221**
    - Biophysics of Multi-cellular Systems and Amorphous Computing
  - **BIOE 222**
    - Introduction to Biomedical Informatics Research Methodology
  - **BIOE 224**
    - Introduction to Imaging and Image-based Human Anatomy
  - or **BIOE 225**
    - Ultrasound Imaging and Therapeutic Applications
  - **BIOE 227**
    - Functional MRI Methods
  - **BIOE 231**
    - Advanced Frameworks and Approaches for Engineering Integrated Genetic Systems
  - **BIOE 260**
    - Tissue Engineering
  - **BIOE 279**
    - Computational Biology: 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 and Differential Calculus of Several Variables 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.

² It is strongly recommended that BIOE 140 Fundamentals for Engineering Biology Lab be taken rather than MATH 51 Linear Algebra and Differential Calculus of Several Variables 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. Further revisions and final endorsement are to be finished by the second Monday in May, when two signed bound copies plus one PC-compatible CD-ROM are to be submitted to the student services officer.
5. Attend the Bioengineering Honors Symposium at the end of Spring Quarter and give a poster or oral presentation, or present in another approved suitable forum.

For more information and application instructions, see the 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 conferment 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 tissue biomechanics. This major prepares students for graduate studies in bioengineering, biomechanics, medicine or related areas.

Requirements

1. Mathematics

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 units minimum; CME sequence is recommended, but MATH sequence is acceptable; see Basic Requirement 1</td>
<td></td>
</tr>
<tr>
<td>CME 102/ENGR 155A 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></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>
</tbody>
</table>

2. Science (22 units Minimum)

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

3. Technology in Society

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>One course required; course must be on School of Engineering</td>
<td>3-5</td>
</tr>
<tr>
<td>Approved Courses list in the UGHB the year taken</td>
<td></td>
</tr>
</tbody>
</table>

Engineering Topics (Engineering Science and Design)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Fundamentals (minimum two courses; see Basic Requirement 3)</td>
<td></td>
</tr>
<tr>
<td>ENGR 14 Intro to Solid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Pick one of the following:</td>
<td></td>
</tr>
<tr>
<td>ENGR 25B Biotechnology</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 80 Introduction to Bioengineering (Engineering Living Matter)</td>
<td></td>
</tr>
<tr>
<td>ENGR 50M Introduction to Materials Science, Biomaterials Emphasis</td>
<td></td>
</tr>
</tbody>
</table>

Engineering Depth

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<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 2</td>
<td>1</td>
</tr>
</tbody>
</table>

Mechanical Engineering/ Biomechanical Engineering Depth

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: 3-5

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 105 Feedback Control Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 102 Foundations of Product Realization</td>
<td>3</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>
<tr>
<td>ME 133 (offered SPR AY 18-19; more information to come)</td>
<td></td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Units</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>MATH 19</td>
</tr>
<tr>
<td>21</td>
<td>MATH 20</td>
</tr>
<tr>
<td>21</td>
<td>MATH 21</td>
</tr>
<tr>
<td>3-5</td>
<td>CS 103</td>
</tr>
<tr>
<td>3-5</td>
<td>CS 109</td>
</tr>
</tbody>
</table>
17 units minimum, see Basic Requirement 2

**PHYSICS 41** Mechanics 4
or **PHYSICS 41I** Mechanics, Concepts, Calculations, and Context

**CHEM 31X** Chemical Principles Accelerated 5

**CHEM 33** Structure and Reactivity of Organic Molecules 5

**BIO 82** Genetics (or HUMBIO 2A) 4

**BIO 83** Biochemistry & Molecular Biology (or BIO 84 or HUMBIO 3A) 4

**BIO 86** Cell Biology (or HUMBIO 4A) 4

### Engineering Fundamentals

**CS 106B** Programming Abstractions 3-5
or **CS 106X** Programming Abstractions (Accelerated)

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

**CS 107** Computer Organization and Systems 3-5

**CS 161** Design and Analysis of Algorithms 3-5

Select one of the following: 3

- **CS 270** Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
- **CS 273A** The Human Genome Source Code
- **CS 274** Representations and Algorithms for Computational Molecular Biology
- **CS 275** Translational Bioinformatics
- **CS 279** Computational Biology: Structure and Organization of Biomolecules and Cells

Research: 6 units of biomedical computation research in any department

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

#### Cellular/Molecular Concentration

Mathematics: Select one of the following:

- **CME 100** Vector Calculus for Engineers
- **STATS 141** Biostatistics
- **MATH 51** Linear Algebra and Differential Calculus of Several Variables

One additional Engineering Fundamental 4

- **BIO 104** Introduction to Biomedical Informatics Research Methodology
- **CHEM 141** The Chemical Principles of Life I (or CHEM 171) 4
- **Cell/Mol Electives** (two courses) 4-6
- **Informatics Electives** (two courses) 4
- **Simulation Electives** (two courses) 4-6
- **Simulation, Informatics, or Cell/Mol Elective** (one course) 4-6

#### Informatics Concentration

Mathematics: Select one of the following:

- **STATS 141** Biostatistics
- **STATS 203** Introduction to Regression Models and Analysis of Variance
- **STATS 205** Introduction to Nonparametric Statistics
- **STATS 215** Statistical Models in Biology

One additional Engineering Fundamental 4

- **Informatics Core** (three courses):
  - **CS 145** Data Management and Data Systems
  - **CS 147** Introduction to Human-Computer Interaction Design

CS 221 Artificial Intelligence: Principles and Techniques
or CS 228 Probabilistic Graphical Models: Principles and Techniques
or CS 229 Machine Learning

One additional course from the previous two lines

- Informatics Electives (three courses) 5,6
- Cellular Electives (two courses) 5,6
- Organs Electives (two courses) 5,6

6-10

### Organs/Organisms Concentration

Mathematics (select one of the following):

- **CME 100** Vector Calculus for Engineers
- **STATS 141** Biostatistics
- **MATH 51** Linear Algebra and Differential Calculus of Several Variables

One additional Engineering Fundamental 4

- **Biology** (two courses):
  - **BIO 112** Human Physiology
  - **CHEM 141** The Chemical Principles of Life I (or BIOE 220)

Two additional Organs Electives 5,6

- Simulation Electives (two courses) 5,6
- Informatics Electives (two courses) 5,6
- Simulation, Informatics, or Organs Elective (one course) 5,6

### Simulation Concentration

Mathematics:

- **CME 100** Vector Calculus for Engineers
  or **MATH 51** Linear Algebra and Differential Calculus of Several Variables

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

### Simulation Core:

- **CME 102** Ordinary Differential Equations for Engineers 5
  or **MATH 53** Ordinary Differential Equations with Linear Algebra
- **ENGR 80** Introduction to Bioengineering (Engineering Living Matter) 4

- **BIOE 101** Systems Biology 3
- **BIOE 103** Systems Physiology and Design 4

- Simulation Electives (two courses) 5,6
- Cellular Elective (one course) 5,6
- Organs Elective (one course) 5,6
- Simulation, Cellular, or Organs Elective (two courses) 5,6

### Total Units 88-104

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2. Research projects require pre-approval of BMC Coordinators.
3. Research units taken as CS 191W Writing Intensive Senior Project or in conjunction with ENGR 199W Writing of Original Research for Engineers fulfill the Writing in the Major (WIM) requirement. CS 272 Introduction to Biomedical Informatics Research Methodology, which does not have to be taken in conjunction with research, also fulfills the WIM requirement.
4. One 3-5 unit course required; CS 106A Programming Methodology may not be used. See Engineering Fundamentals list in Handbook for Undergraduate Engineering Programs or on Approved Courses page at ugub.stanford.edu.
5. The list of electives is continually updated to include all applicable courses. For the current list of electives, see http://bmc.stanford.edu.
A course may only be counted towards one elective or core 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.

A total of 40 Engineering Fundamentals and Core/Depth units must be taken. The core classes only provide 27 Engineering units, so the remaining units must be taken from within the electives.

### Honors Program

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

1. Students apply by submitting a 1-2 page proposal describing the problem the student has chosen to investigate, its significance, and the student’s research plan. This plan must be endorsed by the student’s research and academic advisers, one of whom must be a member of the Academic Council. In making its decision, the department evaluates the overall scope and significance of the student’s proposed work.

2. Students must maintain a 3.5 GPA.

3. Students must complete three quarters of research. All three quarters must be on the same project with the same adviser. A Summer Quarter counts as one quarter of research.
   - Ideally, funding should not be obtained through summer research college sources, but rather through the UAR’s Student Grants Program (http://exploredegrees.stanford.edu/schoolofengineering/%20http://studentgrants.stanford.edu). In no case can the same work be double-paid by two sources.

4. Students must complete a substantial write-up of the research in the format of a publishable research paper. This research paper is expected to be approximately 15-20 pages and must be approved by the student’s research adviser and by a second reader.

5. As the culmination of the honors project, each student presents the results in a public forum. This can either be in the honors presentation venue of the home department of the student’s adviser, or in a suitable alternate venue.

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

### Chemical Engineering

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

#### Mission of the Undergraduate Program in Chemical Engineering

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

#### Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics</strong></td>
<td></td>
</tr>
<tr>
<td>The following sequence or approved AP credit</td>
<td>10</td>
</tr>
<tr>
<td>MATH 19</td>
<td>Calculus</td>
</tr>
<tr>
<td>MATH 20</td>
<td>Calculus</td>
</tr>
<tr>
<td>MATH 21</td>
<td>Calculus</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>5-10</td>
</tr>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
<tr>
<td>MATH 51 &amp; MATH 52</td>
<td>Linear Algebra and Differential Calculus of Several Variables and Integral Calculus of Several Variables</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>5</td>
</tr>
<tr>
<td>CME 102 or MATH 53</td>
<td>Ordinary Differential Equations for Engineers or Ordinary Differential Equations with Linear Algebra</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>4-5</td>
</tr>
<tr>
<td>CME 104 or CME 106</td>
<td>Linear Algebra and Partial Differential Equations for Engineers or Introduction to Probability and Statistics for Engineers</td>
</tr>
<tr>
<td><strong>Science</strong></td>
<td></td>
</tr>
<tr>
<td>CHEM 31X</td>
<td>Chemical Principles Accelerated</td>
</tr>
<tr>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td>CHEM 35</td>
<td>Organic Chemistry of Bioactive Molecules</td>
</tr>
<tr>
<td>PHYSICS 41</td>
<td>Mechanics</td>
</tr>
<tr>
<td>or PHYSICS 41</td>
<td>Mechanics, Concepts, Calculations, and Context</td>
</tr>
<tr>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism</td>
</tr>
<tr>
<td>CHEM 131</td>
<td>Organic Polyfunctional Compounds</td>
</tr>
<tr>
<td><strong>Technology in Society</strong></td>
<td></td>
</tr>
<tr>
<td>One course required, see Basic Requirement 4; course chosen must be on the SoE-Approved Courses list at &lt;ughb.stanford.edu&gt; the year taken.</td>
<td></td>
</tr>
<tr>
<td><strong>Engineering Fundamentals</strong></td>
<td></td>
</tr>
<tr>
<td>Three courses minimum; see Basic Requirement 3</td>
<td></td>
</tr>
<tr>
<td>CHEMENG/ENGR Introduction to Chemical Engineering</td>
<td>4</td>
</tr>
<tr>
<td><strong>Fundamentals Elective from another School of Engineering department</strong></td>
<td>3-5</td>
</tr>
<tr>
<td>See the UGBH for a list of courses.</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 25B</td>
<td>Biotechnology (same as CHEMENG 25B)</td>
</tr>
<tr>
<td>ENGR 25E</td>
<td>Energy, Chemical Transformations for Production, Storage, and Use (same as CHEMENG 25E)</td>
</tr>
</tbody>
</table>

#### Chemical Engineering Depth

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEMENG 10</td>
<td>The Chemical Engineering Profession</td>
<td>1</td>
</tr>
<tr>
<td>CHEMENG 100</td>
<td>Chemical Process Modeling, Dynamics, and Control</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 110</td>
<td>Equilibrium Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 120A</td>
<td>Fluid Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 120B</td>
<td>Energy and Mass Transport</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 130</td>
<td>Separation Processes</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 150</td>
<td>Biochemical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 170</td>
<td>Kinetics and Reactor Design</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 180</td>
<td>Chemical Engineering Plant Design</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 181</td>
<td>Biochemistry I</td>
<td>4</td>
</tr>
</tbody>
</table>
Requirements for graduate studies in engineering. Students for careers in consulting, industry and government, as well as construction, and environmental engineering. The major prepares ideas effectively. The curriculum includes course work in structural, engineering to conduct experiments, design structures and systems the major learn to apply knowledge of mathematics, science, and civil and construction or environmental and water studies. Students in specialties in civil engineering and allows for concentration in structures professional program balances the fundamentals common to many is to provide students with the principles of engineering and the The mission of the undergraduate program in Civil Engineering Mission of the Undergraduate Program in the conferral of the Bachelor of Science in Civil Engineering. Completion of the undergraduate program in Civil Engineering leads to the conferral of the Bachelor of Science in Civil Engineering. 

Mission of the Undergraduate Program in Civil Engineering

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

Requirements

Mathematics and Science 45

45 units minimum; see Basic Requirements 1 and 2

Technology in Society

Chemical Engineering Laboratory A (WIM) 4

Chemical Engineering Laboratory B 4

Physical Chemistry I 4

Physical Chemistry II 3

Physical Chemistry III 3

Select four of the following,\(^1\),\(^2\),\(^3\) 12

Micro and Nanoscale Fabrication Engineering 1

Basic Principles of Heterogeneous Catalysis with Applications in Energy Transformations 1

Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life 1

Polymers for Clean Energy and Water 1

Environmental Microbiology I 1

Biochemistry II 1

Creating New Ventures in Engineering and Science-based Industries 1

Total Units 125-135

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

\(^2\) Any two acceptable except combining 160 and 162.

\(^3\) Students may substitute two of the depth electives with two other science and engineering 3-unit lecture courses. See Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu) for additional details.

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)

Civil Engineering (CE)

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

Environmental and Water Studies Focus

ME 30 Engineering Thermodynamics 3

CxEE 101D Computations in Civil and Environmental Engineering (or CxEE 101S) 3

CxEE 102 Legal Principles in Design, Construction, and Project Delivery (or CxEE 175A (alt years) or CxEE 171 (no longer offered)) 3

CxEE 162E Rivers, Streams, and Canals 3

CxEE 166A Watersheds and Wetlands 4

CxEE 166B Floods and Droughts, Dams and Aqueducts 4

CxEE 172 Air Quality Management 3

CxEE 177 Aquatic Chemistry and Biology 4

CxEE 179A Water Chemistry Laboratory 3

CxEE 179C Environmental Engineering Design 5

(or CxEE 169) Capstone design experience course

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

CxEE 100 Managing Sustainable Building Projects 4

CxEE 101A Mechanics of Materials 4

CxEE 101B Mechanics of Fluids 4

CxEE 101C Geotechnical Engineering 4

CxEE 146S Engineering Economics and Sustainability 3

Specialty courses in either: 39-42

Environmental and Water Studies (see below)

Structures and Construction (see below)

Other School of Engineering Electives 3-0

Total Units 115-117

Mathematics must include CxEE 100 Vector Calculus for Engineers and CxEE 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 GEOLOG 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 GEOLOG 1 is offered for AY 2018-19 is Spring Quarter.

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

Structures and Construction Focus

CEE 102 Legal Principles in Design, Construction, and Project Delivery 3
CEE 120A Building Information Modeling Workshop (or CEE 120S) 3
CEE 156 Building Systems 4
CEE 180 Structural Analysis 4
CEE 181 Design of Steel Structures 4
CEE 182 Design of Reinforced Concrete Structures 4
CEE 183 Integrated Civil Engineering Design Project 4
Select one of the following (beyond the 2 required Engineering Fundamentals):
ENGR 50 Introduction to Materials Science, Nanotechnology Emphasis 4
ENGR 50E Introduction to Materials Science, Energy Emphasis 4
ENGR 50M Introduction to Materials Science, Biomaterials Emphasis 4

Remaining specialty units from:
ENGR 15 Dynamics 3
CME 104 Linear Algebra and Partial Differential Equations for Engineers 5
CEE 101D Computations in Civil and Environmental Engineering (or CEE 101S) 3
CEE 112A Industry Applications of Virtual Design & Construction 2-4
CEE 112B Industry Applications of Virtual Design & Construction 2-4
CEE 122A Computer Integrated Architecture/Engineering/Construction 2
CEE 122B Computer Integrated A/E/C 2
CEE 131A Professional Practice: Mixed-Use Design in an Urban Setting (not offered AY 18-19) 4
CEE 131B Financial Management of Sustainable Urban Systems 3
CEE 141A Infrastructure Project Development 3
CEE 141B Infrastructure Project Delivery 3
CEE 151 Negotiation 3
CEE 155 Introduction to Sensing Networks for CEE 4
CEE 161C Natural Ventilation of Buildings 3
CEE 162E Rivers, Streams, and Canals 3-4
CEE 171 Environmental Planning Methods (no longer offered) 3
CEE 176A Energy Efficient Buildings 3-4
CEE 176B 100% Clean, Renewable Energy and Storage for Everything 3-4
CEE 199 Undergraduate Research in Civil and Environmental Engineering 1-4
CEE 203 Probabilistic Models in Civil Engineering 3-4
One of the following can also count as remaining specialty units. 3-4
CEE 120B Building Information Modeling Workshop 2-4
CEE 130 Architectural Design: 3-D Modeling, Methodology, and Process 3-4
CEE 134B Intermediate Arch Studio 3-4

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

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

Mission of the Undergraduate Program in Computer Science
The mission of the undergraduate program in Computer Science is to develop students' breadth of knowledge across the subject areas of computer 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)—
CS 103 Mathematical Foundations of Computing 5
CS 109 Introduction to Probability for Computer Scientists 5
MATH 19 Calculus 1 3
MATH 20 Calculus 1 3
MATH 21 Calculus 1 3
Plus two electives 2

Science (11 units minimum)—
PHYSICS 41 Mechanics 4
or PHYSICS 41B Mechanics, Concepts, Calculations, and Context
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)—
- CS 106B Programming Abstractions 5
- or CS 106X Programming Abstractions (Accelerated)
- ENGR 40M An Intro to Making: What is EE (or ENGR 40A and ENGR 40B) 3-5

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)

写作在主修中—
选择以下之一：
- CS 181W 计算机伦理与公共政策
- CS 191W 写作密集型高级项目
- CS 194W 软件项目
- CS 210B 软件项目经验与企业合作伙伴
- CS 294W 写作密集型计算机科学研究项目

计算机科学核心 (15 units)—
- CS 107 计算机组织与系统 5
- or CS 107E 计算机系统从基础到上 5
- CS 110 原理计算机系统 5
- CS 161 设计与算法分析 5

Senior Project (3 units)—
- CS 191 高级项目
- CS 191W 写作密集型高级项目
- CS 194 软件项目
- CS 194H 用户界面设计项目
- CS 194W 软件项目
- CS 210B 软件项目经验与企业合作伙伴
- CS 294 写作密集型计算机科学研究项目
- or CS 294W 写作密集型计算机科学研究项目

计算机科学深度 B.S.
选择以下十个计算机科学专业（专业必须至少25个单位7门课程）：

Artificial Intelligence Track—
选择两门来自不同领域的课程:

<table>
<thead>
<tr>
<th>Area I, AI Methods</th>
<th>CS 228 Probabilistic Graphical Models: Principles and Techniques</th>
<th>CS 229 Machine Learning</th>
<th>CS 234 Reinforcement Learning</th>
<th>CS 238 Decision Making under Uncertainty</th>
</tr>
</thead>
</table>

Area II, Natural Language Processing:

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

Area III, Vision:

|-----------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------|

Area IV, Robotics:

<table>
<thead>
<tr>
<th>CS 223A Introduction to Robotics</th>
<th>Select one additional course from the Areas above or from the following:</th>
</tr>
</thead>
</table>

AI Methods:

<table>
<thead>
<tr>
<th>CS 157 Computational Logic</th>
<th>CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning</th>
<th>CS 230 Deep Learning</th>
</tr>
</thead>
</table>

Vision:

<table>
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<tr>
<th>CS 231B</th>
<th>CS 231M</th>
<th>CS 331A</th>
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</table>

Comp Bio:

<table>
<thead>
<tr>
<th>CS 262</th>
<th>CS 279 Computational Biology: Structure and Organization of Biomolecules and Cells</th>
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</table>

Information and the Web:

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

Other:

<table>
<thead>
<tr>
<th>CS 151 Logic Programming</th>
<th>CS 227B General Game Playing</th>
</tr>
</thead>
</table>

Robotics and Control:

<table>
<thead>
<tr>
<th>CS 327A Advanced Robotic Manipulation</th>
<th>CS 329 Topics in Artificial Intelligence (with advisor approval)</th>
</tr>
</thead>
</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>CS 238 Decision Making under Uncertainty</th>
<th>CS 257 Logic and Artificial Intelligence</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CS 275 Translational Bioinformatics</th>
<th>CS 326 Topics in Advanced Robotic Manipulation</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CS 334A Convex Optimization I</th>
<th>CS 364A Convex Optimization I</th>
</tr>
</thead>
</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: 3-4
- CS 221 Artificial Intelligence: Principles and Techniques
- CS 228 Probabilistic Graphical Models: Principles and Techniques
- CS 229 Machine Learning
- CS 231A Computer Vision: From 3D Reconstruction to Recognition

Select one of the following:

- CS 262
- CS 270 Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
- CS 273A The Human Genome Source Code
- CS 274 Representations and Algorithms for Computational Molecular Biology
- CS 275 Translational Bioinformatics
- CS 279 Computational Biology: Structure and Organization of Biomolecules and Cells

One additional course from the lists above or the following: 3-4
- CS 124 From Languages to Information
- CS 145 Data Management and Data Systems
- CS 147 Introduction to Human-Computer Interaction Design
- CS 148 Introduction to Computer Graphics and Imaging
- CS 248 Interactive Computer Graphics

One course selected from the following: 3-4
- CS 108 Object-Oriented Systems Design
- CS 124 From Languages to Information
- CS 131 Computer Vision: Foundations and Applications
- CS 140 Operating Systems and Systems Programming or CS 140E Operating systems design and implementation
- CS 141 Introduction to Computer Sound
- CS 142 Web Applications
- CS 143 Compilers
- CS 144 Introduction to Computer Networking
- CS 145 Data Management and Data Systems
- CS 146 Introduction to Game Design and Development
- CS 147 Introduction to Human-Computer Interaction Design
- CS 148 Introduction to Computer Graphics and Imaging
- CS 149 Parallel Computing
- CS 151 Logic Programming
- CS 154 Introduction to Automata and Complexity Theory
- CS 155 Computer and Network Security
- CS 157 Computational Logic or PHIL 151 Metalogic
- CS 164 Data Structures
- CS 167
- CS 168 The Modern Algorithmic Toolbox
- CS 190 Software Design Studio
- CS 195 Supervised Undergraduate Research (4 units max)
- CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning
- CS 205B
- CS 210A Software Project Experience with Corporate Partners
- CS 217 Hardware Accelerators for Machine Learning
- CS 221 Artificial Intelligence: Principles and Techniques
- CS 223A Introduction to Robotics
- CS 224N Natural Language Processing with Deep Learning
- CS 224S Spoken Language Processing
- CS 224U Natural Language Understanding
- CS 224W Analysis of Networks
- CS 225A Experimental Robotics
- CS 227B General Game Playing
- CS 228 Probabilistic Graphical Models: Principles and Techniques
- CS 229 Machine Learning
- CS 229T Statistical Learning Theory
- CS 230 Deep Learning
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- CS 231B
- CS 231M
- CS 231N Convolutional Neural Networks for Visual Recognition
- CS 232 Digital Image Processing
- CS 233 Geometric and Topological Data Analysis
- CS 234 Reinforcement Learning
- CS 236 Deep Generative Models
- CS 238 Decision Making under Uncertainty
- CS 240 Advanced Topics in Operating Systems
- CS 242 Programming Languages
- CS 243 Program Analysis and Optimizations
- CS 244 Advanced Topics in Networking
- CS 244B Distributed Systems
- CS 245 Database Systems Principles
- CS 246 Mining Massive Data Sets
- CS 247 Human-Computer Interaction Design Studio
- CS 248 Interactive Computer Graphics
- CS 251 Cryptocurrencies and blockchain technologies
- CS 252 Analysis of Boolean Functions
- CS 254 Computational Complexity
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>CS 255</td>
<td>Introduction to Cryptography</td>
<td>3</td>
</tr>
<tr>
<td>CS 261</td>
<td>Optimization and Algorithmic Paradigms</td>
<td>3</td>
</tr>
<tr>
<td>CS 262</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CS 263</td>
<td>Algorithms for Modern Data Models</td>
<td>3</td>
</tr>
<tr>
<td>CS 264</td>
<td>Beyond Worst-Case Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CS 265</td>
<td>Randomized Algorithms and Probabilistic Analysis</td>
<td>3</td>
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<tr>
<td>CS 266</td>
<td></td>
<td>3</td>
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<tr>
<td>CS 267</td>
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<td>3</td>
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<tr>
<td>CS 269I</td>
<td>Incentives in Computer Science</td>
<td>3</td>
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<tr>
<td>CS 270</td>
<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
<td>3</td>
</tr>
<tr>
<td>CS 272</td>
<td>Introduction to Biomedical Informatics Research Methodology</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 273A</td>
<td>The Human Genome Source Code</td>
<td>3</td>
</tr>
<tr>
<td>CS 273B</td>
<td>Deep Learning in Genomics and Biomedicine</td>
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<tr>
<td>CS 274</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
<td>3-4</td>
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<td>CS 275</td>
<td>Translational Bioinformatics</td>
<td>4</td>
</tr>
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<td>CS 276</td>
<td>Information Retrieval and Web Search</td>
<td>3</td>
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<tr>
<td>CS 277</td>
<td>Social Computing</td>
<td>3</td>
</tr>
<tr>
<td>CS 279</td>
<td>Computational Biology: Structure and Organization of Biomolecules and Cells</td>
<td>3</td>
</tr>
<tr>
<td>CS 348B</td>
<td>Computer Graphics: Image Synthesis Techniques</td>
<td>3-4</td>
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<tr>
<td>CS 348C</td>
<td>Computer Graphics: Animation and Simulation</td>
<td>3</td>
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<tr>
<td>CS 348K</td>
<td>Visual Computing Systems</td>
<td>3-4</td>
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<tr>
<td>CS 371</td>
<td>Computational Biology in Four Dimensions</td>
<td>3</td>
</tr>
<tr>
<td>CS 374</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CME 108</td>
<td>Introduction to Scientific Computing</td>
<td>3</td>
</tr>
<tr>
<td>EE 180</td>
<td>Digital Systems Architecture</td>
<td>4</td>
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<tr>
<td>EE 263</td>
<td>Introduction to Linear Dynamical Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 282</td>
<td>Computer Systems Architecture</td>
<td>3</td>
</tr>
<tr>
<td>EE 364A</td>
<td>Convex Optimization I</td>
<td>3</td>
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<tr>
<td>MS&amp;E 152</td>
<td>Introduction to Decision Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>STATS 206</td>
<td>Applied Multivariate Analysis</td>
<td>3</td>
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<tr>
<td>STATS 315A</td>
<td>Modern Applied Statistics: Learning</td>
<td>2-3</td>
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<tr>
<td>STATS 315B</td>
<td>Modern Applied Statistics: Data Mining</td>
<td>2-3</td>
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<tr>
<td>GENE 211</td>
<td>Genomics</td>
<td>3</td>
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<td>One course from the following:</td>
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<td>CS 147</td>
<td>Data Management and Data Systems</td>
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<tr>
<td>CS 148</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td>3-5</td>
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<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>3-4</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
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<td>CS 262</td>
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<td>CS 270</td>
<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
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</tr>
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<td>The Human Genome Source Code</td>
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<td>CS 273B</td>
<td>Deep Learning in Genomics and Biomedicine</td>
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<tr>
<td>CS 274</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
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<td>CS 275</td>
<td>Translational Bioinformatics</td>
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<td>Computational Biology: Structure and Organization of Biomolecules and Cells</td>
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<tr>
<td>CS 371</td>
<td>Computational Biology in Four Dimensions</td>
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<td>CS 373</td>
<td>Statistical and Machine Learning Methods for Genomics</td>
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<tr>
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<td>One course selected from the list above or the following:</td>
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<tr>
<td>CHEMENG 150</td>
<td>Biochemical Engineering</td>
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<td>CHEMENG 174</td>
<td>Environmental Microbiology</td>
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<td>APPPHYS 294</td>
<td>Cellular Biophysics</td>
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<tr>
<td>BIO 104</td>
<td>Advance Molecular Biology: Epigenetics and Proteostasis</td>
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<td>BIO 118</td>
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<td>Advanced Cell Biology</td>
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<td>BIO 217</td>
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<td>BIO 230</td>
<td>Molecular and Cellular Immunology</td>
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<td>CHEM 141</td>
<td>The Chemical Principles of Life I</td>
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<td>CHEM 171</td>
<td>Physical Chemistry I</td>
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<td>BIO 218</td>
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<tr>
<td>BIO 241</td>
<td>Biological Macromolecules</td>
<td>3-5</td>
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<td>One course from the following:</td>
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<td>BIO 220</td>
<td>Introduction to Imaging and Image-based Human Anatomy</td>
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<tr>
<td>CHEMENG 150</td>
<td>Biochemical Engineering</td>
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<tr>
<td>CHEMENG 174</td>
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<td>CS 262</td>
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<tr>
<td>CS 274</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
<td>3-4</td>
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<tr>
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<td>CS 371</td>
<td>Computational Biology in Four Dimensions</td>
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<td>CS 374</td>
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<td>3</td>
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<td>ME 281</td>
<td>Biomechanics of Movement</td>
<td>3</td>
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<tr>
<td>APPPHYS 294</td>
<td></td>
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<tr>
<td>BIO 104</td>
<td>Advance Molecular Biology: Epigenetics and Proteostasis</td>
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<td>BIO 112</td>
<td>Human Physiology</td>
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<td>BIO 118</td>
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<tr>
<td>BIO 158</td>
<td>Developmental Neurobiology</td>
<td>4</td>
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<tr>
<td>BIO 183</td>
<td>Theoretical Population Genetics</td>
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<td>Molecular and Cellular Immunology</td>
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<td>CHEM 171</td>
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<td>BIOC 241</td>
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<tr>
<td>DEVELOP 210</td>
<td>Developmental Biology</td>
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</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</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>EE 108</td>
<td>Digital System Design &amp; Digital Systems Architecture</td>
<td>6-8</td>
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<tr>
<td>EE 109</td>
<td>Digital Systems Design Lab</td>
<td>8</td>
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<tr>
<td>EE 271</td>
<td>Introduction to VLSI Systems</td>
<td>8</td>
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<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td>8</td>
</tr>
<tr>
<td>CS 144</td>
<td>Introduction to Computer Networking</td>
<td>8</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>
<td>8</td>
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<tr>
<td>CS 217</td>
<td>Hardware Accelerators for Machine Learning</td>
<td>8</td>
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<tr>
<td>CS 240E</td>
<td>Advanced Topics in Networking</td>
<td>8</td>
</tr>
<tr>
<td>EE 273</td>
<td>Digital Systems Engineering</td>
<td>8</td>
</tr>
<tr>
<td>EE 282</td>
<td>Computer Systems Architecture</td>
<td>8</td>
</tr>
<tr>
<td>CS 205L</td>
<td>Continuous Mathematical Methods with an Emphasis on Machine Learning</td>
<td>8</td>
</tr>
<tr>
<td>CS 223A</td>
<td>Introduction to Robotics</td>
<td>8</td>
</tr>
<tr>
<td>ME 210</td>
<td>Introduction to Mechatronics</td>
<td>8</td>
</tr>
<tr>
<td>ENGR 105</td>
<td>Feedback Control Design</td>
<td>8</td>
</tr>
<tr>
<td>CS 225A</td>
<td>Experimental Robotics</td>
<td>8</td>
</tr>
<tr>
<td>CS 231A</td>
<td>Computer Vision: From 3D Reconstruction to Recognition</td>
<td>8</td>
</tr>
<tr>
<td>ENGR 205</td>
<td>Introduction to Control Design Techniques</td>
<td>8</td>
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<tr>
<td>ENGR 207B</td>
<td>Linear Control Systems II</td>
<td>8</td>
</tr>
<tr>
<td>CS 240</td>
<td>Advanced Topics in Operating Systems</td>
<td>8</td>
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<tr>
<td>CS 241</td>
<td>Embedded Systems Workshop</td>
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<tr>
<td>CS 244</td>
<td>Advanced Topics in Networking</td>
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<tr>
<td>CS 244B</td>
<td>Distributed Systems</td>
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<tr>
<td>EE 179</td>
<td>Analog and Digital Communication Systems</td>
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</table>

Satisfy the requirements of one of the following concentrations:

1) Digital Systems Concentration

- CS 140 Operating Systems and Systems Programming
- EE 109 Digital Systems Design Lab
- EE 271 Introduction to VLSI Systems
- CS 144 Introduction to Computer Networking
- CS 149 Parallel Computing
- CS 190 Software Design Studio
- CS 217 Hardware Accelerators for Machine Learning
- CS 240E Advanced Topics in Networking
- EE 273 Digital Systems Engineering
- EE 282 Computer Systems Architecture
- 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
- CS 225A Experimental Robotics
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- ENGR 205 Introduction to Control Design Techniques
- ENGR 207B Linear Control Systems II

2) Robotics and Mechatronics Concentration

- CS 144 Introduction to Computer Networking
- CS 149 Parallel Computing
- CS 190 Software Design Studio
- CS 217 Hardware Accelerators for Machine Learning
- CS 240E Advanced Topics in Networking
- EE 273 Digital Systems Engineering
- EE 282 Computer Systems Architecture
- 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
- CS 225A Experimental Robotics
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- ENGR 205 Introduction to Control Design Techniques
- ENGR 207B Linear Control Systems II

3) Networking Concentration

- CS 140 Operating Systems and Systems Programming
- EE 109 Digital Systems Design Lab
- EE 271 Introduction to VLSI Systems
- CS 144 Introduction to Computer Networking
- CS 149 Parallel Computing
- CS 190 Software Design Studio
- CS 217 Hardware Accelerators for Machine Learning
- CS 240E Advanced Topics in Networking
- EE 273 Digital Systems Engineering
- EE 282 Computer Systems Architecture
- 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
- CS 225A Experimental Robotics
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- ENGR 205 Introduction to Control Design Techniques
- ENGR 207B Linear Control Systems II

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

Graphics Track—

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 148</td>
<td>Introduction to Computer Graphics and Imaging</td>
<td>8</td>
</tr>
<tr>
<td>&amp; CS 248</td>
<td>Introduction to Interactive Computer Graphics</td>
<td>8</td>
</tr>
</tbody>
</table>

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
- 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—

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td>4</td>
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<tr>
<td>CS 247</td>
<td>Human-Computer Interaction Design Studio</td>
<td>4</td>
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</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
- CS 210A Software Project Experience with Corporate Partners
- CS 278 Social Computing
- CS 376 Human-Computer Interaction Research
Any CS 377 'Topics in HCI' of three or more units
CS 448B Data Visualization
ME 216M Introduction to the Design of Smart Products

At least two additional courses from above list, the general CS electives list, or the following: 4

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 272 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 Performative 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
PSYCH 252 Statistical Methods for Behavioral and Social Sciences
PSYCH 253 High-Dimensional Methods for Behavioral and Neural Data

Information Track—

CS 124 From Languages to Information 4
CS 145 Data Management and Data Systems 4
Two courses, from different areas: 6-9

1) Information-based AI applications
CS 224N Natural Language Processing with Deep Learning
CS 224S Spoken Language Processing
CS 229 Machine Learning
CS 233 Geometric and Topological Data Analysis
CS 234 Reinforcement Learning

2) Database and Information Systems
CS 140 Operating Systems and Systems Programming
or CS 140E Operating systems design and implementation
CS 142 Web Applications
CS 151 Logic Programming
CS 245 Database Systems Principles
CS 246 Mining Massive Data Sets
CS 341 Project in Mining Massive Data Sets
CS 345 (Offered occasionally)

3) Information Systems in Biology
CS 262
CS 270 Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
CS 274 Representations and Algorithms for Computational Molecular Biology

4) Information Systems on the Web
CS 224W Analysis of Networks

STATS 203 Introduction to Regression Models and Analysis of Variance
EDUC 191 Introduction to Survey Research
HUMBIO 82A Qualitative Research Methodology
ME Design-
ME 101 Visual Thinking
ME 115A Introduction to Human Values in Design
ME 203 Design and Manufacturing
ME 210 Introduction to Mechatronics
ME 216A Advanced Product Design: Needfinding

EDUC 236 Beyond Bits and Atoms: Designing Technological Tools
EDUC 281 Technology for Learners
EDUC 289 Educating Young STEM Thinkers
EDUC 338 Innovations in Education
EDUC 342 Child Development and New Technologies
MS&E-
MS&E 185 Global Work
MS&E 331

Computer Music-
MUSIC 220A Fundamentals of Computer-Generated Sound
MUSIC 220B Compositional Algorithms, Psychoacoustics, and Computational Music
MUSIC 220C Research Seminar in Computer-Generated Music
MUSIC 250A Physical Interaction Design for Music
MUSIC 256A Music, Computing, Design I: The Art of Design

Optional Elective 4

Units
## Systems Track —

### Units

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>CS 140E Operating systems design and implementation</td>
<td></td>
</tr>
</tbody>
</table>

Select one of the following:

- CS 143 Compilers
- EE 180 Digital Systems Architecture

Two additional courses from the list above or the following:

- 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:

- 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 Computer Networks (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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 154</td>
<td>Introduction to Automata and Complexity Theory</td>
<td>4</td>
</tr>
</tbody>
</table>

Select one of the following:

- CS 168 The Modern Algorithmic Toolbox
- CS 255 Introduction to Cryptography
- CS 261 Optimization and Algorithmic Paradigms
- CS 264 Beyond Worst-Case Analysis
- CS 265 Randomized Algorithms and Probabilistic Analysis
- CS 268 Geometric Algorithms

Two additional courses from the list above or the following:

- CS 143 Compilers

## Unspecialized Track —

### Units

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 154</td>
<td>Introduction to Automata and Complexity Theory</td>
<td>4</td>
</tr>
</tbody>
</table>

Select one of the following:

- 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:

- 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:

- CS 151 Logic Programming
- CS 155 Computer and Network Security
- CS 157 Computational Logic or PHIL 151 Metalogic
- CS 166 Data Structures
- CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning
- CS 228 Probabilistic Graphical Models: Principles and Techniques
- CS 233 Geometric and Topological Data Analysis
- CS 236 Deep Generative Models
- CS 242 Programming Languages
- CS 250 Algebraic Error Correcting Codes
- CS 251 Cryptocurrencies and blockchain technologies
- CS 252 Analysis of Boolean Functions
- CS 254 Computational Complexity
- CS 259 (with permission of undergraduate advisor)
- CS 262
- CS 263 Algorithms for Modern Data Models
- CS 266
- CS 267
- CS 269I Incentives in Computer Science
- CS 352 Pseudo-Randomness
- CS 354 Topics in Intractability: Unfulfilled Algorithmic Fantasies (Not given this year)
- CS 355 Advanced Topics in Cryptography (Not given this year)
- CS 357 (Not given this year)
- CS 358 Topics in Programming Language Theory
- CS 359 Topics in the Theory of Computation (with permission of undergraduate advisor)
- CS 364A
- CS 369 Topics in Analysis of Algorithms (with permission of undergraduate advisor)
- CS 374
- MS&E 310 Linear Programming

Track Electives: at least three additional courses from the lists above or the following:

- CS 269G Almost Linear Time Graph Algorithms
- CME 302 Numerical Linear Algebra
- CME 305 Discrete Mathematics and Algorithms
- PHIL 152 Computability and Logic
Undergraduate Engineering Programs (UGHB)

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs for further information.

Individually 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)

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 bioelectronics 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

<table>
<thead>
<tr>
<th>Select one sequence: May also be satisfied with AP Calculus.</th>
<th>10</th>
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</thead>
<tbody>
<tr>
<td>MATH 19</td>
<td>Calculus</td>
</tr>
<tr>
<td>&amp; MATH 20</td>
<td>and Calculus</td>
</tr>
<tr>
<td>&amp; MATH 21</td>
<td>and Calculus</td>
</tr>
</tbody>
</table>

Select one 2-course sequence:

<table>
<thead>
<tr>
<th>CME 100</th>
<th>Vector Calculus for Engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp; CME 102</td>
<td>and Ordinary Differential Equations for Engineers (Same as ENGR 154 and ENGR 155A)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATH 51</th>
<th>Linear Algebra and Differential Calculus of Several Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp; MATH 53</td>
<td>and Ordinary Differential Equations with Linear Algebra</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>EE 103</th>
<th>Introduction to Matrix Methods (Preferred)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 113</td>
<td>Linear Algebra and Matrix Theory</td>
</tr>
<tr>
<td>CS 103</td>
<td>Mathematical Foundations of Computing</td>
</tr>
</tbody>
</table>

Statistics/Probability. Select one:

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

Science

Minimum 12 units

Select one sequence: 12
Select one. Students may select their Design course from any Design Requirements.

Select one. A single course can concurrently meet the WIM and Writing in the Major (WIM)

Minimum 17 units, 5 courses: 1-2 Required, 1 WIM/Design and 2-3 Disciplinary Area

Physics of Electrical Engineering.

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)

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

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 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.

1. 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.
2. MATH 52 may be taken in place of MATH 51. CME 102 can be taken in place of MATH 53.
3. EE 42 may be used in place of PHYSICS 43. CME 102 can be taken in place of PHYSICS 43. There are no prerequisites for ENGR 40A and ENGR 40B or ENGR 40M.
4. Modified for later enrollment, EE 42 may be used in place of PHYSICS 43. CME 102 can be taken in place of PHYSICS 43. There are no prerequisites for ENGR 40A and ENGR 40B or ENGR 40M.
5. For upper division students, a 200-level seminar in their disciplinary area will be accepted, on petition.
6. Students may petition to have either PHYSICS 65 or the combination of PHYSICS 45 and PHYSICS 70 count as an alternative to EE 65.
7. 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.
8. 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.

Disciplinary Areas

<table>
<thead>
<tr>
<th>Hardware and Software</th>
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<tbody>
<tr>
<td>EE 103</td>
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<td>EE 180</td>
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<td>EE 109</td>
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<td><strong>Physical Technology and Science</strong></td>
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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:

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**Science**

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**Technology in Society**

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**Engineering Fundamentals**

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

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**Engineering Physics Depth (core)**

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

**Advanced Mathematics:**

One advanced math elective such as

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**Advanced Mechanics:**

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**Numerical Methods**

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

**Engineering Physics (EPHYS)**

Completion of the undergraduate program in Engineering Physics leads to the conferment 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
### Writing in the Major (WIM)

Select one of the following: **3-5**
- **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** Heat Transfer and Advanced Thermal Systems (for Energy Systems specialty only)
- **MATS1 161** Energy Materials Laboratory (Okay for Materials Science and Renewable Energy specialties)
- **MATS1 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

### 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
- **ME 210** 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
- **MATS1 156** Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution
- **MATS1 302** Solar Cells
- **MATS1 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
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
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 <ughb.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
3-5 in visual, oral/written communication, and modeling/analysis

Specialty Courses, in either
Coastal environments (see below)
or freshwater environments (see below)
or urban environments (see below)

Total Units 96-98

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

Energy 173S Electricity Economics 3

or

ENERGY 171 Energy Infrastructure, Technology and Economics 3

Water Systems
- CEE 165C Water Resources Management 3
- 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
- or
- 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
Freshwater Environments Focus Area (37 units)
Required
CEE 199  Infrastructure Project Development 3
CEE 141B  Infrastructure Project Delivery 3
CEE 224X  Disasters, Decisions, Development in Sustainable Urban Systems (CEE) 3-5
CEE 224Y  Sustainable Urban Systems Project 3-5
CEE 224Z  Sustainable Urban Systems Project 3-5
CEE 226E  Advanced Topics in Integrated, Energy-Efficient Building Design 3
CEE 235  CapaCity Design Studio 5
CEE 243  Intro to Urban Sys Engrg 3
CEE 199  Undergraduate Research in Civil and Environmental Engineering 3-4

Coastal Environments Focus Area (37 units)
Required
CEE 70  Environmental Science and Technology 3
CEE 101B  Mechanics of Fluids 4
CEE 162F  Coastal Processes 3
CEE 175A  California Coast: Science, Policy, and Law 3-4
or
CEE 162I  Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation 3

Electives
CEE 162I  Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation 3
CEE 166A  Watersheds and Wetlands 4
CEE 166B  Floods and Dams and Aqueducts 4
CEE 230  Urban Development and Governance 3
or
EARTHSYS 238  Land Use Law 3
CEE 174A  Providing Safe Water for the Developing and Developed World 3
CEE 174B  Wastewater Treatment: From Disposal to Resource Recovery 3
CEE 175A  California Coast: Science, Policy, and Law 3-4
CEE 177  Aquatic Chemistry and Biology 4
CEE 230  Urban Development and Governance 3
CEE 265E  Adaptation to Sea Level Rise and Extreme Weather Events 3
CEE 272  Coastal Contaminants 3-4
BIOHOPK 150H  Ecological Mechanics 3
BIOHOPK 163H  Oceanic Biology 4
BIO 30  Ecology for Everyone 4
or
BIO 81  Introduction to Ecology 4
or
BIOHOPK 81  Introduction to Ecology 4
or
BIOHOPK 172H  Marine Ecology: From Organisms to Ecosystems 5
or
EARTHSYS 116  Ecology of the Hawaiian Islands 4
or
OSPAUSTL 25  Coral Reef Ecosystems 3
ESS 8  The Oceans: An Introduction to the Marine Environment 4
or
BIOHOPK 182H  Stanford at Sea (Oceanography portion) 4
(only 4 units allowed to count)

Capstone (1 class required)
CEE 141A  Infrastructure Project Development 3
CEE 179C  Environmental Engineering Design 5
CEE 224X  Disasters, Decisions, Development in Sustainable Urban Systems (CEE) 1-5
CEE 224Y  Sustainable Urban Systems Project 3-5
CEE 224Z  Sustainable Urban Systems Project 3-5
CEE 235  CapaCity Design Studio 5
CEE 199  Undergraduate Research in Civil and Environmental Engineering 3-4

EARTHYS 141  Remote Sensing of the Oceans 3-4
EARTHYS 151  Biological Oceanography 3-4
to be taken concurrently with
EARTHYS 152  Marine Chemistry 3-4
OSPSANTG 76  Urban Water (Spr 18-19 only) 4

Capstone (1 class required)
CEE 126  International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development 4-5
CEE 141A  Infrastructure Project Development 3
and goal of the major, and indicate how it relates to her or his projected major. In the statement, the student should make clear the motivation for each proposal should begin with a statement describing the proposed course work to bring the total number of units to at least 90 and at most 120. Students may take additional courses pertinent to their IDMEN major. The program prepares students for careers in government and the corporate sector, and for graduate study.

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 120. 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.

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

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

Honors in Individually Designed Major in Engineering

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.

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 | 23
CME 100 Vector Calculus for Engineers
or MATH 51 Linear Algebra and Differential Calculus of Several Variables
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: | 8-10
CHEM 31B Chemical Principles II
or CHEM 31X Chemical Principles Accelerated
CHEM 33 Structure and Reactivity of Organic Molecules
PHYSICS 41 Mechanics
or PHYSICS 22 Mechanics, Fluids, and Heat
PHYSICS 43 Electricity and Magnetism
or PHYSICS 45 Electricity, Magnetism, and Optics
BIO 81 Introduction to Ecology
BIO 82 Genetics
BIO 83 Biochemistry & Molecular Biology
BIO 84 Physiology
BIO 85 Evolution
BIO 86 Cell Biology

Math, Science, or Statistics Elective from SoE approved lists. | 3
Up to ten units of AP/IB Calculus, MATH 19, 20, 21, 41, or 42. | 10

Technology in Society

Select one of the following; see SoE Basic Requirement 4 | 3-5
AA 252 Techniques of Failure Analysis
COMM 120W Digital Media in Society
BIOE 131 Ethics in Bioengineering
CS 181 Computers, Ethics, and Public Policy
ENGR 131 Ethical Issues in Engineering
ME 267 Ethics and Equity in Transportation Systems
MS&E 193 Technology and National Security
POLSCI 114S International Security in a Changing World
STS 1 The Public Life of Science and Technology

Engineering Fundamentals

Two courses; see SoE Basic Requirement 3 | 8-10
CS 106A Programming Methodology

Select one of the following:
ENGR 10 Introduction to Engineering Analysis
ENGR 14 Intro to Solid Mechanics
ENGR 15 Dynamics
ENGR 20 Introduction to Chemical Engineering

Engineering Depth

Core Courses (all six required) | 25-27
CS 106B Programming Abstractions
or CS 106X Programming Abstractions (Accelerated)
ECON 50 Economic Analysis I
MS&E 108 Senior Project (WIM)
MS&E 111 Introduction to Optimization
or MS&E 111X Introduction to Optimization (Accelerated)
MS&E 140 Accounting for Managers and Entrepreneurs
or MS&E 140X Financial Accounting Concepts and Analysis
MS&E 180 Organizations: Theory and Management

Area Courses (see below) | 27
Choose four or five courses (minimum 15 units) from a primary area and two courses (minimum 6 units) from each of the other two areas.

Depth Areas

Finance and Decision Area | 6-15
Students choosing F&D as their primary area must take at least two of ECON 51, MS&E 145 (or 245A), and MS&E 152 (or 252), as part of their 15 units
Introductory (no prerequisites)
MS&E 147 Finance and Society for non-MBAs
MS&E 152 Introduction to Decision Analysis
Intermediate (has prerequisites and/or appropriate for juniors and seniors)
MS&E 145 Introduction to Investment Science
MS&E 146 Corporate Financial Management
MS&E 252 Decision Analysis I: Foundations of Decision Analysis

Advanced (intended primarily for graduate students, but may be taken by advanced undergraduates)
MS&E 245A Investment Science
MS&E 245B Advanced Investment Science
MS&E 246 Financial Risk Analytics
MS&E 250A Engineering Risk Analysis
MS&E 250B Project Course in Engineering Risk Analysis

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

Methods
MS&E 112 Mathematical Programming and Combinatorial Optimization
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

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  Causes and Cures for Organizational Friction
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:
MATH 51  Linear Algebra and Differential Calculus of Several Variables
CME 102/ ENGR 154  Vector Calculus for Engineers

Select one of the following:
MATH 52  Integral Calculus of Several Variables
CME 104/ ENGR 155B  Linear Algebra and Partial Differential Equations for Engineers

Select one of the following:
MATH 53  Ordinary Differential Equations with Linear Algebra
CME 102/ ENGR 155A  Ordinary Differential Equations for Engineers

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.

Technology in Society
One course minimum 3

Engineering Fundamentals
Two courses minimum
Select one of the following:
- **ENGR 50**: Introduction to Materials Science, Nanotechnology Emphasis
- **ENGR 50E**: Introduction to Materials Science, Energy Emphasis
- **ENGR 50M**: Introduction to Materials Science, Biomaterials Emphasis

At least one additional course

### Materials Science Fundamentals: All of the following courses: 16
- 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

Two of the following courses: 8
- MATSCI 151: Microstructure and Mechanical Properties
- MATSCI 152: Electronic Materials Engineering
- MATSCI 156: Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution
- MATSCI 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

### Materials Science & Engineering Depth 16

Four laboratory courses for Sixteen units; Four units must be WIM
- MATSCI 161: 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

Focus Area Options 5-6

Total Units 103-107

---

1. See a list of approved math courses at ughb.stanford.edu (https://ughb.stanford.edu/courses-and-planning/approved-courses). AP/IB Credit (https://ughb.stanford.edu/petitions/ap-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 (https://ughb.stanford.edu/courses-and-planning/approved-courses). AP/IB Credit (https://ughb.stanford.edu/petitions/ap-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 (https://ughb.stanford.edu/courses-and-planning/approved-courses). Course chosen must be on the approved list the year taken.

---

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

### Chemical Engineering
- CHEM 171: Physical Chemistry I
- CHEMENG 130: Separation Processes
- CHEMENG 140: Micro and Nanoscale Fabrication Engineering
- CHEMENG 150: Biochemical Engineering

### 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
### School of Engineering

#### Course Offerings

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 142</td>
<td>Engineering Electromagnetics (Formerly EE 141)</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics</td>
</tr>
<tr>
<td>ME 210</td>
<td>Introduction to Mechatronics</td>
</tr>
<tr>
<td>MATSCI 343</td>
<td>Organic Semiconductors for Electronics and Photonics</td>
</tr>
<tr>
<td>MATSCI 346</td>
<td>Nanophotonics</td>
</tr>
</tbody>
</table>

#### Energy Technology

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 293B</td>
<td>Fundamentals of Energy Processes</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics</td>
</tr>
<tr>
<td>CEE 107A</td>
<td>Understanding Energy</td>
</tr>
<tr>
<td>EE 293B</td>
<td>Fundamentals of Energy Processes</td>
</tr>
<tr>
<td>MATSCI 156</td>
<td>Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution</td>
</tr>
</tbody>
</table>

#### Materials Characterization Techniques

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATSCI 320</td>
<td>Nanocharacterization of Materials</td>
</tr>
<tr>
<td>MATSCI 321</td>
<td>Transmission Electron Microscopy</td>
</tr>
<tr>
<td>MATSCI 322</td>
<td>Transmission Electron Microscopy Laboratory</td>
</tr>
<tr>
<td>MATSCI 323</td>
<td>Thin Film and Interface Microanalysis</td>
</tr>
<tr>
<td>MATSCI 326</td>
<td>X-Ray Science and Techniques</td>
</tr>
<tr>
<td>CHEMENG 345</td>
<td>Fundamentals and Applications of Spectroscopy</td>
</tr>
<tr>
<td>BIO 232</td>
<td>Advanced Imaging Lab in Biophysics</td>
</tr>
<tr>
<td>APPPHYS 201</td>
<td>Electrons and Photons (PHOTON 201)</td>
</tr>
</tbody>
</table>

#### Mechanical Behavior & Design

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 240</td>
<td>Analysis of Structures</td>
</tr>
<tr>
<td>AA 256</td>
<td>Mechanics of Composites</td>
</tr>
<tr>
<td>MATSCI 198</td>
<td>Mechanical Properties of Materials</td>
</tr>
<tr>
<td>MATSCI 241</td>
<td>Mechanical Behavior of Nanomaterials</td>
</tr>
<tr>
<td>MATSCI 358</td>
<td>Fracture and Fatigue of Materials and Thin Film Structures</td>
</tr>
<tr>
<td>ME 80</td>
<td>Mechanics of Materials</td>
</tr>
<tr>
<td>or CEE 101A</td>
<td>Mechanics of Materials</td>
</tr>
<tr>
<td>ME 203</td>
<td>Design and Manufacturing</td>
</tr>
</tbody>
</table>

#### Nanoscience

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 240</td>
<td>Introduction to Micro and Nano Electromechanical Systems</td>
</tr>
<tr>
<td>MATSCI 241</td>
<td>Mechanical Behavior of Nanomaterials</td>
</tr>
<tr>
<td>MATSCI 316</td>
<td>Nanoscale Science, Engineering, and Technology</td>
</tr>
<tr>
<td>MATSCI 320</td>
<td>Nanocharacterization of Materials</td>
</tr>
<tr>
<td>MATSCI 346</td>
<td>Nanophotonics</td>
</tr>
<tr>
<td>MATSCI 347</td>
<td>Magnetic materials in nanotechnology, sensing, and energy</td>
</tr>
<tr>
<td>MATSCI 380</td>
<td>Nano-Biotechnology</td>
</tr>
</tbody>
</table>

#### Physics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 70</td>
<td>Foundations of Modern Physics</td>
</tr>
<tr>
<td>PHYSICS 110</td>
<td>Advanced Mechanics</td>
</tr>
<tr>
<td>PHYSICS 120</td>
<td>Intermediate Electricity and Magnetism I</td>
</tr>
<tr>
<td>PHYSICS 121</td>
<td>Intermediate Electricity and Magnetism II</td>
</tr>
<tr>
<td>PHYSICS 130</td>
<td>Quantum Mechanics I</td>
</tr>
<tr>
<td>PHYSICS 131</td>
<td>Quantum Mechanics II</td>
</tr>
<tr>
<td>PHYSICS 134</td>
<td>Advanced Topics in Quantum Mechanics</td>
</tr>
<tr>
<td>PHYSICS 170</td>
<td>Thermodynamics, Kinetic Theory, and Statistical Mechanics I</td>
</tr>
<tr>
<td>PHYSICS 171</td>
<td>Thermodynamics, Kinetic Theory, and Statistical Mechanics II</td>
</tr>
</tbody>
</table>

### 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

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (http://ughb.stanford.edu).
Mechanical Engineering (ME)
Completion of the undergraduate program in Mechanical Engineering leads to the conferral of the Bachelor of Science in Mechanical Engineering.

Mission of the Undergraduate Program in Mechanical Engineering
The mission of the undergraduate program in Mechanical Engineering is to provide students with a balance of 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 an engineering discipline or other fields where a broad engineering background is useful.

Core Requirements
Mathematics
24 units minimum; see Basic Requirement 1
CME 102/ ENGR 155A Ordinary Differential Equations for Engineers 5
or MATH 53 Ordinary Differential Equations with Linear Algebra
Select one of the following: 3-5
CME 106/ ENGR 155C Introduction to Probability and Statistics for Engineers
STATS 110 Statistical Methods in Engineering and the Physical Sciences
STATS 116 Theory of Probability
Plus additional courses to total min. 24
Science
20 units minimum; see Basic Requirement 2
CHEM 31X Chemical Principles Accelerated 5
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 3-5
Engineering Fundamentals
Two courses minimum; see Basic Requirement 3
ENGR 14 Intro to Solid Mechanics 3
ENGR 70A Programming Methodology (same as CS 106A) 5
Engineering Core
Minimum of 68 Engineering Science and Design ABET units; see Basic Requirement 5
ME 1 Introduction to Mechanical Engineering 3
ENGR 15 Dynamics 3
ME 80 Mechanics of Materials 3
ME 30 Engineering Thermodynamics 3
ME 70 Introductory Fluids Engineering 3
ME 131A Heat Transfer 3
ME 102 Foundations of Product Realization 3
ME 103 Product Realization: Design and Making 3
ME 112 Mechanical Systems Design 2

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

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 (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 338 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) 1-3
ENGR 240 Introduction to Micro and Nano Electromechanical Systems
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 161</td>
<td>Dynamic Systems, Vibrations and Control</td>
<td>3-4</td>
</tr>
<tr>
<td>ME 181</td>
<td>Deliverables: A Mechanical Engineering Design Practicum</td>
<td>3</td>
</tr>
<tr>
<td>CME 106</td>
<td>Introduction to Probability and Statistics for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ME 210</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>ME 263</td>
<td>The Chair</td>
<td>4</td>
</tr>
<tr>
<td>ME 298</td>
<td>Silversmithing and Design</td>
<td>3-4</td>
</tr>
<tr>
<td>ME 309</td>
<td>Finite Element Analysis in Mechanical Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 324</td>
<td>Precision Engineering</td>
<td>4</td>
</tr>
</tbody>
</table>

**Thermo, Fluids, and Heat Transfer Concentration**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 132</td>
<td>Intermediate Thermodynamics</td>
<td>4</td>
</tr>
<tr>
<td>ME 133</td>
<td>(offered SPR 18-19; more information to come)</td>
<td>4</td>
</tr>
<tr>
<td>ME 149</td>
<td>Mechanical Measurements</td>
<td>3</td>
</tr>
</tbody>
</table>

**Thermo, Fluids, and Heat Transfer Electives**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 250</td>
<td>Internal Combustion Engines</td>
<td>1-5</td>
</tr>
<tr>
<td>ME 257</td>
<td>Gas-Turbine Design Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ME 351A</td>
<td>Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ME 351B</td>
<td>Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ME 352A</td>
<td>Radiative Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>ME 352B</td>
<td>Fundamentals of Heat Conduction</td>
<td>3</td>
</tr>
<tr>
<td>ME 352C</td>
<td>Convective Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>ME 362A</td>
<td>Physical Gas Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 370A</td>
<td>Energy Systems I: Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 370B</td>
<td>Energy Systems II: Modeling and Advanced Concepts</td>
<td>4</td>
</tr>
<tr>
<td>ME 371</td>
<td>Combustion Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>AA 283</td>
<td>Aircraft and Rocket Propulsion</td>
<td>3</td>
</tr>
</tbody>
</table>

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

2. ME 112 fulfills the WIM requirement.

3. ME 170A and ME 170B are a 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 in consecutive quarters.

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

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

**BSME 1.0 Student Notes**

Those students (primarily juniors and seniors) who are completing BSME 1.0 from prior years should refer to bulletins from the academic year that corresponds with their program sheet.
The 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. The joint major program (JMP) is designed to provide a unique opportunity to gain mastery in two fields through a cohesive, transdisciplinary course of study 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.)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 115A</td>
<td>Introduction to Human Values in Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 115B</td>
<td>Product Design Methods</td>
<td>4</td>
</tr>
<tr>
<td>ME 120</td>
<td>History and Philosophy of Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 215C</td>
<td>Analytical Product Design</td>
<td>5</td>
</tr>
<tr>
<td>ME 216A</td>
<td>Advanced Product Design: Needfinding</td>
<td>4</td>
</tr>
<tr>
<td>ME 216B</td>
<td>Advanced Product Design: Implementation 1</td>
<td>6</td>
</tr>
<tr>
<td>ME 216C</td>
<td>Advanced Product Design: Implementation 2</td>
<td>6</td>
</tr>
</tbody>
</table>

1. Math requirements can be met with the Math 19-21 series, the MATH 50's series, and/or the CME 100 series; STATS 60 is recommended.
2. AP units can be applied; have these approved by SoE Dean's Office before final quarter.
3. The Joint Major approved science list available at [http://uघb.stanford.edu](http://uघb.stanford.edu). PSYCH electives numbered 30-200 or HUMBIO 82A or HUMBIO 160 are pre-approved.
4. ME 112 meets the Writing in the Major (WIM) requirement for Product Design.
5. ME 215C is the only course that can be waived if a student takes a 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. ME 216B and ME 216C with ME 206A and ME 206B Design for Extreme Affordability.
6. 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.

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (UGHB) ([http://phoong. stanford.edu](http://phoong. 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://exploreddegrees. stanford.edu/undergraduat degreesandprograms/#jointmajor text](http://exploreddegrees. stanford.edu/undergraduat degreesandprograms/#jointmajor text))" 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—Computer Science and a selected humanities field—it does so in a way that reduces the total unit requirement for each major.

### Declaring a Joint Major Program

To declare the joint major, students must first declare each major through Axess, and then submit the Declaration of Change of Undergraduate
Major, Minor, Honors, or Degree Program. The Major-Minor and Multiple Major Course Approval Form 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. Students may also consult the Student Services Center with questions concerning dropping the joint major.

**Transcript and Diploma**

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

**Minor in the School of Engineering**

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

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

1. A set of courses totaling not less than 20 and not more than 36 units, with a minimum of six courses of at least 3 units each. These courses must be taken for a letter grade except where letter grades are not offered, and a minimum GPA of 2.0 within the minor course list must be maintained (departments may require a higher GPA if they choose).
2. The set of courses should be sufficiently coherent as to present a body of knowledge within a discipline or subdiscipline.
3. Prerequisite mathematics, statistics, or science courses, such as those normally used to satisfy the school’s requirements for a department major, may not be used to satisfy the requirements of the minor; conversely, engineering courses that serve as prerequisites for subsequent courses must be included in the unit total of the minor program.
4. Courses used for the major and/or minor core must not be duplicated within any other of the student’s degree programs; that is, students may not overlap (double-count) courses for completing 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>
<th>12 Core Units, 24 Total Program Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 21</td>
<td>Engineering of Systems ²</td>
</tr>
<tr>
<td>AA 100</td>
<td>Introduction to Aeronautics and Astronautics</td>
</tr>
<tr>
<td>AA 131</td>
<td>Space Flight</td>
</tr>
<tr>
<td>AA 141</td>
<td>Atmospheric Flight</td>
</tr>
<tr>
<td>AA Electives</td>
<td>Choose 4 courses</td>
</tr>
<tr>
<td>AA 101</td>
<td>Introduction to Aero Fluid Mechanics ¹</td>
</tr>
<tr>
<td>AA 102</td>
<td>Introduction to Applied Aerodynamics</td>
</tr>
<tr>
<td>AA 103</td>
<td>Air and Space Propulsion</td>
</tr>
<tr>
<td>AA 111</td>
<td>Introduction to Aerospace Computational Engineering ¹</td>
</tr>
<tr>
<td>AA 135</td>
<td>Introduction to Space Policy ¹</td>
</tr>
<tr>
<td>AA 151</td>
<td>Lightweight Structures</td>
</tr>
<tr>
<td>AA 156</td>
<td>Mechanics of Composite Materials</td>
</tr>
<tr>
<td>AA 171</td>
<td>Autonomous Systems ¹</td>
</tr>
<tr>
<td>AA 173</td>
<td>Flight Mechanics and Controls ¹</td>
</tr>
<tr>
<td>AA 175</td>
<td>Embedded Programming ¹</td>
</tr>
<tr>
<td>AA 272C</td>
<td>Global Positioning Systems</td>
</tr>
<tr>
<td>AA 279A</td>
<td>Space Mechanics</td>
</tr>
<tr>
<td>ENGR 105</td>
<td>Feedback Control Design</td>
</tr>
</tbody>
</table>

¹ This course will be offered in the future. Please see our website for future course offerings. For courses not yet offered please contact the Aero/Astro 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:

<table>
<thead>
<tr>
<th>Chemical Engineering Minor</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 20</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 100</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 110</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 120A</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 120B</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 170</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 185A</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 171</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 180</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 140</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 142</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 160</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 162</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 174</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 181</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Units 36
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 and Differential Calculus of Several Variables 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) (http://www.stanford.edu/dept/registrar/bulletin/jhbarton@stanford.edu)), Program Director for Architectural Design, is the undergraduate minor adviser in Architectural Design. Students must consult the appropriate adviser when developing their minor program, and obtain approval of the finalized study list from them.

Computer Science (CS) Minor

The following core courses fulfill the minor requirements. Prerequisites include the standard mathematics sequence through MATH 51 (or CME 100).

<table>
<thead>
<tr>
<th>Core:</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>Programming Abstractions</td>
<td></td>
</tr>
<tr>
<td>Programming Abstractions (Accelerated)</td>
<td></td>
</tr>
<tr>
<td>Core:</td>
<td></td>
</tr>
<tr>
<td>CS 103</td>
<td>5</td>
</tr>
<tr>
<td>Mathematical Foundations of Computing</td>
<td></td>
</tr>
<tr>
<td>or CS 107</td>
<td>5</td>
</tr>
<tr>
<td>Computer Organization and Systems</td>
<td></td>
</tr>
<tr>
<td>or CS 107E</td>
<td></td>
</tr>
<tr>
<td>Computer Systems from the Ground Up</td>
<td></td>
</tr>
<tr>
<td>CS 109</td>
<td>5</td>
</tr>
<tr>
<td>Introduction to Probability for Computer Scientists</td>
<td></td>
</tr>
<tr>
<td>Electives (choose two courses from different areas):</td>
<td></td>
</tr>
<tr>
<td>Artificial Intelligence—</td>
<td></td>
</tr>
<tr>
<td>CS 124</td>
<td>4</td>
</tr>
<tr>
<td>From Languages to Information</td>
<td></td>
</tr>
</tbody>
</table>

CS 221 Artificial Intelligence: Principles and Techniques 4
CS 229 Machine Learning 3-4
Human-Computer Interaction—
CS 147 Introduction to Human-Computer Interaction Design 4
Software—
CS 108 Object-Oriented Systems Design 4
CS 110 Principles of Computer Systems 5
Systems—
CS 140 Operating Systems and Systems Programming 4
or CS 140E Operating systems design and implementation 4
CS 143 Compilers 4
CS 144 Introduction to Computer Networking 4
CS 145 Data Management and Data Systems 4
CS 148 Introduction to Computer Graphics and Imaging 4
Theory—
CS 154 Introduction to Automata and Complexity Theory 4
CS 157 Computational Logic 3
CS 161 Design and Analysis of Algorithms 5

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

Electrical Engineering (EE) Minor

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

<table>
<thead>
<tr>
<th>Select one:</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 42 Introduction to Electromagnetics and Its Applications</td>
<td>5</td>
</tr>
<tr>
<td>EE 65 Modern Physics for Engineers</td>
<td></td>
</tr>
<tr>
<td>ENGR 40A Introductory Electronics</td>
<td></td>
</tr>
<tr>
<td>&amp; ENGR 40B Introductory Electronics Part II</td>
<td></td>
</tr>
<tr>
<td>ENGR 40M An Intro to Making: What is EE</td>
<td></td>
</tr>
<tr>
<td>Select one:</td>
<td>8</td>
</tr>
<tr>
<td>Option I:</td>
<td></td>
</tr>
<tr>
<td>EE 101A Circuits I</td>
<td></td>
</tr>
<tr>
<td>EE 101B Circuits II</td>
<td></td>
</tr>
<tr>
<td>Option II:</td>
<td></td>
</tr>
<tr>
<td>EE 102A Signal Processing and Linear Systems I</td>
<td></td>
</tr>
<tr>
<td>EE 102B Signal Processing and Linear Systems II</td>
<td></td>
</tr>
<tr>
<td>Option III:</td>
<td></td>
</tr>
<tr>
<td>EE 102A Signal Processing and Linear Systems I</td>
<td></td>
</tr>
<tr>
<td>EE 103 Introduction to Matrix Methods</td>
<td></td>
</tr>
<tr>
<td>Option IV:</td>
<td></td>
</tr>
<tr>
<td>EE 108 Digital System Design</td>
<td>4</td>
</tr>
<tr>
<td>EE 180 Digital Systems Architecture</td>
<td></td>
</tr>
</tbody>
</table>

In addition, four letter-graded EE courses at the 100-level or higher must be taken (12 units minimum). CS 107 is required as a prerequisite for EE 180, but can count as one of the four classes.

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...
The following courses are required to fulfill the minor requirements:

**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>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 100 Vector Calculus for Engineers or MATH 51 Linear Algebra and Differential Calculus of Several Variables</td>
<td>5</td>
</tr>
<tr>
<td>CS 106A Programming Methodology</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minor requirements (seven courses; all letter-graded)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS&amp;E 111 Introduction to Optimization or MS&amp;E 111X Introduction to Optimization (Accelerated)</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 120 Probabilistic Analysis</td>
<td>5</td>
</tr>
<tr>
<td>MS&amp;E 121 Introduction to Stochastic Modeling</td>
<td>4</td>
</tr>
<tr>
<td>MS&amp;E 125 Introduction to Applied Statistics</td>
<td>4</td>
</tr>
<tr>
<td>MS&amp;E 180 Organizations: Theory and Management</td>
<td>4</td>
</tr>
<tr>
<td>Electives (select any two 100- or 200-level MS&amp;E courses)</td>
<td>6</td>
</tr>
</tbody>
</table>

**Recommended courses**

In addition to the required background and minor courses, it is recommended that students also take the following courses.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 50 Economic Analysis</td>
<td>5</td>
</tr>
<tr>
<td>MS&amp;E 140 Accounting for Managers and Entrepreneurs (may be used as one of the required electives above) or MS&amp;E 140X Financial Accounting Concepts and Analysis</td>
<td>2-4</td>
</tr>
</tbody>
</table>

1 Students completing a calculus-based probability course such as CS 109 or STATS 116 for their major, may substitute another MS&E course for MS&E 120.

**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>Engineering Fundamentals</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select one of the following:</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 50 Introduction to Materials Science, Nanotechnology Emphasis</td>
<td></td>
</tr>
<tr>
<td>ENGR 50E Introduction to Materials Science, Energy Emphasis</td>
<td></td>
</tr>
<tr>
<td>ENGR 50M Introduction to Materials Science, Biomaterials Emphasis</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials Science Fundamentals and Engineering Depth</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select six of the following:</td>
<td>24</td>
</tr>
<tr>
<td>MATSCI 142 Quantum Mechanics of Nanoscale Materials</td>
<td></td>
</tr>
<tr>
<td>MATSCI 143 Materials Structure and Characterization</td>
<td></td>
</tr>
<tr>
<td>MATSCI 144 Thermodynamic Evaluation of Green Energy Technologies</td>
<td></td>
</tr>
<tr>
<td>MATSCI 145 Kinetics of Materials Synthesis</td>
<td></td>
</tr>
<tr>
<td>MATSCI 151 Microstructure and Mechanical Properties</td>
<td></td>
</tr>
<tr>
<td>MATSCI 152 Electronic Materials Engineering</td>
<td></td>
</tr>
<tr>
<td>MATSCI 156 Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution</td>
<td></td>
</tr>
<tr>
<td>MATSCI 158 Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life</td>
<td></td>
</tr>
<tr>
<td>MATSCI 160 Nanomaterials Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATSCI 161 Energy Materials Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATSCI 162 X-Ray Diffraction Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATSCI 163 Mechanical Behavior Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATSCI 164 Electronic and Photonic Materials and Devices Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATSCI 165 Nanoscale Materials Physics Computation Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATSCI 190 Organic and Biological Materials</td>
<td></td>
</tr>
<tr>
<td>MATSCI 192 Materials Chemistry</td>
<td></td>
</tr>
<tr>
<td>MATSCI 193 Atomic Arrangements in Solids</td>
<td></td>
</tr>
<tr>
<td>MATSCI 194 Thermodynamics and Phase Equilibria</td>
<td></td>
</tr>
<tr>
<td>MATSCI 195 Waves and Diffraction in Solids</td>
<td></td>
</tr>
<tr>
<td>MATSCI 196 Defects in Crystalline Solids</td>
<td></td>
</tr>
<tr>
<td>MATSCI 197 Rate Processes in Materials</td>
<td></td>
</tr>
<tr>
<td>MATSCI 198 Mechanical Properties of Materials</td>
<td></td>
</tr>
<tr>
<td>MATSCI 199 Electronic and Optical Properties of Solids</td>
<td></td>
</tr>
</tbody>
</table>

Total Units 28

**Mechanical Engineering (ME) Minor**
The following courses fulfill the minor requirements:

<table>
<thead>
<tr>
<th>General Minor*</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 14 Intro to Solid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 15 Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 1 Introduction to Mechanical Engineering</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>
</tbody>
</table>

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

**Master of Science in Engineering**

The M.S. in Engineering is available to students who wish to follow an interdisciplinary program of study that does not conform to a normal graduate program in a department.

### Thermosciences Minor **

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 14</td>
<td>Intro to Solid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ME 30</td>
<td>Engineering Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 70</td>
<td>Introductory Fluids Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ME 149</td>
<td>Mechanical Measurements</td>
<td>3</td>
</tr>
<tr>
<td>ME 132</td>
<td>Intermediate Thermodynamics</td>
<td>4</td>
</tr>
<tr>
<td>ME 133</td>
<td>(offered SPR 18-19; more information to come)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Units:</strong></td>
<td><strong>22</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Mechanical Design Minor ***

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<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>ME 80</td>
<td>Mechanics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>ME 1</td>
<td>Introduction to Mechanical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ME 102</td>
<td>Foundations of Product Realization</td>
<td>3</td>
</tr>
<tr>
<td>ME 103</td>
<td>Product Realization: Design and Making</td>
<td>3</td>
</tr>
<tr>
<td>ME 112</td>
<td>Mechanical Systems Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 113</td>
<td>Mechanical Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>ME 210</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>ME 220</td>
<td>Introduction to Sensors</td>
<td>3-4</td>
</tr>
<tr>
<td><strong>Total units:</strong></td>
<td><strong>24-25</strong></td>
<td></td>
</tr>
</tbody>
</table>

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

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

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

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 cotermals 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 this 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,

*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).

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<td>Introductory Science of Materials</td>
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