

School of Engineering

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Courses given in Engineering have the subject code ENGR. For a complete list of subject codes, see Appendix B.

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 (in formation during 2002-03), Chemical Engineering, Civil and Environmental Engineering, Computer Science, Electrical Engineering, Management Science and Engineering, Material Science and Engineering, and Mechanical Engineering. These departments and one interdisciplinary program, Scientific Computing and Computational Mathematics, are responsible for graduate curricula, research activities, and the departmental components of the undergraduate curricula. In research where faculty interest and competence embrace both engineering and the supporting sciences, there are numerous programs within the school as well as several interschool activities, including the Alliance for Innovative Manufacturing at Stanford, Center for Integrated Systems, Center for Materials Research, Center on Polymer Interfaces and Macromolecular Assemblies, Center for Space Science and Astrophysics, Joint Institute for Aeronautics, the NIH Biotechnology Graduate Training Grant in Chemical Engineering, and a program in Product Design. Petroleum Engineering is offered through the School of Earth Sciences.

Instruction in engineering is offered primarily during the 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

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 available online at <http://ughb.stanford.edu> and provides detailed descriptions of all undergraduate programs in the school, as well as additional information about extracurricular programs and services. A hard copy version is also available from the Office of Student Affairs in Terman Engineering Center, Room 201. Because it is published in the summer, and updates are made to the web site on a continuing basis, the handbook reflects the most up-to-date information for the academic year and is the definitive reference for all undergraduate engineering programs.

Accreditation—The Accreditation Board for Engineering and Technology (ABET) accredits college engineering programs nationwide using criteria and standards developed and accepted by U.S. engineering communities. At Stanford, the following undergraduate programs are accredited: Chemical Engineering, Civil Engineering, Electrical Engineering, the Industrial Engineering program in Management Science and Engineering, and 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 undergraduate handbook 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 Terman 201.

Policy on Satisfactory/No Credit Grading and Minimum Grade Point Average—All courses taken to satisfy major requirements (including the requirements for mathematics, science, engineering fundamentals, Technology in Society, and engineering depth) for all engineering students (including both department and School of Engineering majors) must be taken for a letter grade if the instructor offers that option.

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

ADMISSION

Students admitted to the University may declare a major in the School of Engineering if they elect to do so; no additional courses or examinations are required for admission to the school.

RECOMMENDED PREPARATION

FRESHMEN

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

TRANSFER STUDENTS

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

Transfer credit is given for courses taken elsewhere whenever the courses are equivalent or substantially similar to Stanford courses in scope and rigor. The policy of the School of Engineering is to study each transfer student’s preparation and make a reasonable evaluation of the courses taken prior to transfer. Inquiries may be addressed to the Senior Associate Dean for Student Affairs and the Assistant Director for Undergraduate Studies in the School of Engineering at Stanford. For more information, see the transfer credit section of the *School of Engineering Undergraduate Handbook* web site at <http://ughb.stanford.edu>.

DEGREE PROGRAM OPTIONS

3/2 DEGREE PROGRAMS

The 3/2 engineering program at Stanford is a special opportunity that allows a student to complete three years at a liberal arts college followed by two years at Stanford. After completing the five-year program, the student is awarded two degrees, a B.S. in Engineering from Stanford and a B.A. from the liberal arts college.

Candidates for this special dual-degree program are considered as regular transfer applicants and are expected to meet the same admissions standards as all other transfer candidates. This requirement distinguishes the Stanford 3/2 program from those of most other institutions that “guarantee” admission to students who meet certain grade and course requirements and are recommended by the 3/2 coordinator of the liberal arts college.

All 3/2 transfer applicants are required to submit the transfer application forms, a final secondary school transcript, official transcripts from each college attended, and the official results of either the College Board Scholastic Aptitude Test (SAT) or the American College Test (ACT). All materials must be submitted by the regular transfer deadline.

In addition to the above mentioned documents, dual-degree candidates are required to have a letter of recommendation sent from the liberal arts college 3/2 program coordinator. Also required is a letter from the appropriate academic dean indicating the intention of the liberal arts college to award the B.A. degree, not the B.S. degree, upon completion of the required number of course credits. Applications are only accepted from students attending a liberal arts college that does not offer a degree program in engineering.

BACHELOR OF ARTS AND SCIENCE (B.A.S.)

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” section of this bulletin.

DUAL AND COTERMINAL DEGREE 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. Usually five years are needed for a combined program.

Dual B.A. and B.S. Degree Program—To qualify for both degrees, a student must (1) complete the stated University and department require-

ments for each degree, (2) complete 15 full-time quarters, or three full-time quarters after completing 180 units, and (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. To qualify for both degrees, a student must (1) complete three full-time quarters (or the equivalent) after completing 180 units, (2) complete, in addition to the 180 units required for the bachelor’s degree, the number of units required by the graduate department for the master’s degree (not fewer than the University minimum of 45 units), (3) complete the requirements for the bachelor’s degree (department, school, and University) and apply for the degree at the appropriate time at the Office of the Registrar, and (4) complete the department and University requirements for the master’s degree and apply for the degree at Degree Progress in the Registrar’s Office.

Admission to the coterminal program requires admission to graduate status by the pertinent department. Admission criteria vary from department to department.

Procedure for Applying for Admission to Coterminal Degree Programs—A Stanford undergraduate may apply (using the University coterminal application form) for admission to the coterminal bachelor’s and master’s degree program after the beginning of the eighth quarter of undergraduate work and no later than the end of the 11th quarter of undergraduate work, and at least four quarters in advance of the anticipated date of conferral of the master’s degree. Students seeking a graduate degree in engineering must apply to the pertinent department.

BACHELOR OF SCIENCE

Departments within the School of Engineering offer programs leading to the B.S. degree in the following fields: Chemical Engineering, Civil Engineering, Computer Science, Electrical Engineering, Environmental Engineering, Management Science and Engineering, Materials Science and Engineering, and Mechanical Engineering. The School of Engineering itself offers interdisciplinary programs leading to the B.S. degree in Engineering with specializations in Aeronautics and Astronautics, Computer Systems Engineering, and Product Design. In addition, students may elect a B.S. with an Individually Designed Major in Engineering.

Petroleum Engineering—Petroleum Engineering is offered by the School of Earth Sciences. Consult the “Petroleum Engineering” section of this bulletin for requirements.

School of Engineering majors who anticipate summer jobs or career positions associated with the oil industry may wish to consider enrolling in Engineering 120, Fundamentals of Petroleum Engineering.

Programs in Manufacturing—Programs in manufacturing are available at the undergraduate, M.S., and Ph.D. 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 (IDMs).

SCHOOL OF ENGINEERING MAJORS

The School of Engineering offers the degree of Bachelor of Science in Engineering. School of Engineering programs must be approved by the Undergraduate Council of the school. There are two types of programs: majors that have been proposed by cognizant faculty groups and have been pre-approved by the council, and Individually Designed Majors. At present, there are five pre-approved majors: Aeronautics and Astronautics, Biomechanical, Biomedical Computation, Computer Systems Engineering, and Product Design. Total units required for these majors must be at least 90 and not more than 107. These majors are not accredited by ABET.

AERONAUTICS AND ASTRONAUTICS (AA)

Mathematics (24 units):	
MATH 53 or 130, or ENGR 155A	3-5
MATH electives	(See Basic Requirement 1)
Science (18 units):	
PHYSICS 53. Mechanics	4
PHYSICS 55. Electricity and Magnetism	4
One further physics course	3
Science electives (see Basic Requirement 2)	9
Technology in Society (3-5 units):	
One course	(See Basic Requirement 4)
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by the department):	
ENGR 14. Statics	3
ENGR 30. Engineering Thermodynamics	3
ENGR 70A. or 70X. Programming (recommended)	5
Engineering Depth (39 units):	
AA 100. Introduction to Aeronautics and Astronautics	3
AA 190. Directed Research in Aeronautics and Astronautics (WIM)	3
ENGR 15. Dynamics	3
CEE 101A. Mechanics of Materials	
or ME 80. Stress, Strain, and Strength	3-4
ME 161. Dynamic Systems	
or PHYSICS 110. Intermediate Mechanics	4
ME 70. Introductory Fluids Engineering	4
ME 131A. Heat Transfer	4
Depth Area I ¹	6
Depth Area II ¹	6
Engineering Electives ²	3
Total	100-106

These requirements are subject to change. The final requirements are published along with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- 1 Two of the following areas:
- Fluids (AA 200A, 210A, 214A, 280 or 283; ME 131B)
 - Structures (AA 240A, 240B, 256)
 - Dynamics and Controls (AA242A, 271A, 279; ENGR 105, 205)
 - Systems Design (AA 241A, 241B, 236A, 236B)

- 2 Electives are to be approved by the adviser, and might be from the depth area lists, or courses such as AA 201A, 210B, 252; ENGR 206, 209A, 209B; or other upper-division Engineering courses.

BIOMECHANICAL (BME)

Mathematics (21 units minimum):	(See Basic Requirement 1)
Science (22 units minimum, should include 1 year of Chemistry or Physics (12 units) and 2 courses of HUMBIO core or Biocore (10 units), additional units from School of Engineering approved list):	
BIOSCI 44X. Biology Labs	4
BIOSCI/HUMBIO (Biocore/HUMBIO Core)	5
BIOSCI/HUMBIO (Biocore/HUMBIO Core)	5
Technology in Society (3-5 units):	
one course	(See Basic Requirement 4)
Additional courses as necessary (refer to ME Department)	
Engineering Topics (Engineering Science and Design):	
Engineering Fundamentals	
(three courses required, one from School of Engineering approved list)	
ENGR 14. Applied Mechanics: Statics	3
ENGR 25. Introduction to Biotechnology	3
Engineering Depth:	
ENGR 15. Dynamics	3
ENGR 30. Engineering Thermodynamics	3
ME 70. Introductory Fluids Engineering	4
ME 80. Stress, Strain, and Strength	3
ME 389. Bioengineering and Biodesign Forum	1
Options to complete the ME depth sequence	
(select 3 courses, minimum 9 units)	
ENGR 105. Feedback Control Design	3
ENGR 210. Introduction to Mechatronics	4
ME 101. Visual Thinking	3
ME 103D. Engineering Drawing and Design	1
ME 112. Mechanical Systems Design	4
ME 113. Mechanical System Design	4
ME 131A. Heat Transfer	4
ME 131B. Fluid Mechanics: Compressible Flow and Turbomachinery	3
ME 140. Advanced Thermal Systems	4
ME 161. Dynamic Systems	4
ME 203. Manufacturing and Design	3
ME 220. Introduction to Sensors	3
Options to complete the BME depth sequence	
(select 3 course, minimum 9 units):	
ME 281. Biomechanics of Movement	3
ME 284. Cardiovascular Bioengineering	3

ME 289. Skeleton Development & Evolution	3
ME 294. Medical Device Design	3
Total	94-103

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

BIOMEDICAL COMPUTATION (BMC)

Mathematics (21 unit minimum):	(See Basic Requirement 1)
MATH 41. Calculus	5
MATH 42. Calculus	5
STATS 116. Theory of Probability ¹	5
CS 103. Discrete Structures (X, or A and B)	4-6
Science (17 units minimum):	(See Basic Requirement 2)
PHYSICS 53. Mechanics	4
CHEM 31. Chemical Principles	4
CHEM 33. Structure and Reactivity	4
BIOSCI 41. Evolution, Genetics, Biochem	5
BIOSCI 42. Cell Biology, Dev. Biology, and Neurobiology	5
BIOSCI 43. Physiology, Ecology, Behavioral	5
Engineering Fundamentals (two different courses required)	
CS 106. Programming Abstractions (X, or A and B)	5
For the second required course, see concentrations	
Technology in Society	
(one course required, 3-5 units):	(See Basic Requirement 4)
Engineering Depth (46 units minimum required):	
Programming:	
CS 107. Programming Paradigms	5
Core:	
BIOMEDIN 210. Intro Biomedical Informatics	3
Research:	
CS191W Research Project (WIM) ²	6
or ME 191 Research Project ²	
Engineering Depth Concentration: (choose one of the following concentrations)	
Cellular/Molecular Concentration:	
Mathematics: plus one of the following courses:	
MATH 51. Advanced Calculus	5
STATS 141. Biostatistics	5
Engineering Fundamentals:	
Elective ³	3
Biology: (four courses)	
BIOSCI 126. Cell Bio: Molecular	4
BIOSCI 129. Cell Bio: Dynamics	4
BIOC 200. Biochemistry	5
BIOSCI 203. Advanced Genetics	4
Simulation Breadth (two courses) ^{4,5}	6
Informatics Breadth (two courses) ^{5,6}	6
General Breadth (one course) ^{5,7}	6
Informatics Concentration:	
Mathematics:	
STATS 141. Biostatistics	4
Engineering Fundamentals:	
Elective ³	3
Informatics Core (two courses)	
CS 145. Databases	4
CS 161. Design and Analysis of Algorithms	4
CS 121/221. Artificial Intelligence	3
Informatics Electives (three courses) ⁸	9
Cellular Breadth (two courses) ⁹	6
Organs Breadth (two courses) ¹⁰	6
Organs/Organisms Concentration:	
Mathematics: one of the following courses:	
MATH 51. Advanced Calculus	5
STATS 141. Biostatistics	5
Engineering Fundamentals:	
Elective ³	3
Biology (three courses)	
BIOSCI 112. Human physiology	4
BIOC 200. Biochemistry	5
SBIO 211. Structure of Cells and Tissues	7
Simulation Breadth (two courses) ^{4,5}	6
Informatics Breadth (two course) ^{5,6}	6
General Breadth (one course) ^{5,11}	6
Simulation Concentration:	
Mathematics:	
MATH 51. Advanced Calculus I	5
MATH 53 or ENGR 155A. Advanced Calculus II	5
MATH 52 or ENGR 155B. Advanced Calculus III	5
Science:	
PHYSICS 51 or PHYSICS 55	3
Engineering Fundamentals:	
See requirement in Simulation Core	
Simulation Core: (two courses) ¹²	6
Two courses from ENGR 14,15, 30, and ME 80	6

Simulation Breadth (two courses) ¹³	6
Cellular Breadth (one course) ⁹	6
Organs Breadth (one course) ¹¹	3
Total	90-107

- MS&E 120 or EE 178 are acceptable substitutes for STATS 116.
- CS 201 also fulfills the "Writing in the Major" requirement.
- One course required, 3 to 5 units. See Fundamentals list in *School of Engineering Handbook*.
- The simulation electives must be chosen from the following set: ENGR 14, ENGR 15, ENGR 30, ME 33, ME 80, ME 180, ME 181, ME 184A, CS 223A, CS 248, CS 277, CS 326A, SBIO 228, CHEM 171.
- A total of 40 engineering units must be taken. The core classes only provide 27 engineering units, so the remaining units must be taken from within the electives.
- The informatics electives must be chosen from the following set: CS 161, CS 145, CS 121, CS 147, CS 222, CS 228, CS 229, CS 262, BIOMEDIN 211, BIOMEDIN 214, BIOC 218, MS&E 252, STATS 206, STATS 315A, GENE 211.
- The additional elective must be chosen from the lists in Cellular/Molecular concentration of simulation electives, informatics electives, or within the following set: BIOSCI 132, BIOSCI 133, SBIO 228, BIOSCI 214, CS 262, BIOMEDIN 214, BIOC 218, GENE 211, GENE 344.
- The informatics electives must be chosen from the following set: CS 147, CS 222, CS 228, CS 229, CS 262, BIOMEDIN 211, BIOMEDIN 214, BIOC 218, MS&E 252, STATS 206, STATS 315A, GENE 211.
- The cellular electives must be chosen from the following set: BIOSCI 126, BIOSCI 129, BIOC 200, BIOSCI 203, BIOSCI 132, BIOSCI 133, SBIO 228, BIOSCI 214, CS 262, BIOMEDIN 214, BIOC 218, GENE 211, GENE 344.
- The organs electives must be chosen from the following set: BIOSCI 122, BIOC 200, SBIO 211, SURG 101, BIOSCI 158, BIOSCI 214, BIOSCI 230, BIOSCI 283, ME 180, ME 181, ME 184A, DBIO 210.
- The additional elective must be chosen from the lists in Organs/Organisms concentration of simulation electives, informatics electives or within the following set: SURG 101, BIOSCI 158, BIOSCI 214, BIOSCI 283, ME 180, ME 181, ME 184A, DBIO 210.
- Different subsets of these courses are required for different continuation courses in the track.
- The simulation electives must be chosen from the following set: ME 180, ME 181, ME 184A CS 223A, CS 248, CS 277, CS 326A, SBIO 228, CHEM 171.

COMPUTER SYSTEMS ENGINEERING (CSE)

Mathematics (23 units):	
MATH 41, 42, 51. Calculus	15
MATH 52 or 53. Multivariable Math	5
MATH 103 or 113. Linear Algebra ¹	3
Science (12 units):	
PHYSICS 51. Light and Heat	4
PHYSICS 53. Mechanics	4
PHYSICS 55. Electricity and Magnetism	4
Technology in Society (3-5 units):	
one course (See Basic Requirement 4)	
Engineering Fundamentals (13 units):	
ENGR 40. Electronics	5
ENGR 70X. Programming Methodology and Abstractions or CS 106A and B	5
Elective ²	
Writing in the Major (one course):	
CS 191W, 194, and 201 fulfill this requirement	
Depth (53 units): Major changes to the depth area are coming this year. Contact the undergraduate course adviser (ug-advisor@cs.stanford.edu) or check the CS web page (http://cse.stanford.edu/resources/CourseAdvisor/index.html) for updates.	
CS 103X. Discrete Structures or CS 103A and B	4 or 6
CS 107. Programming Paradigms	5
CS 108. Object-Oriented Systems Design	4
CS 140. Operating Systems or CS 143. Compilers	4
EE 101. Circuits	3
EE 111, 112. Electronics	8
EE 121. Digital Design Laboratory	4
EE 182. Computer Organization	4
EE 183. Advanced Logic Laboratory	3
EE 271. Introduction to VLSI Systems	3
Electives ³	6-9
Senior Project (CS 191, 191W, or 194) ⁴	3
Total	103-105

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- Completion of MATH 52 and 53 satisfies the MATH 103/113 requirement.
- One course required, 3 to 5 units. See list in the *Handbook for Undergraduate Engineering Programs* at <http://ughb.stanford.edu>.
- Students who take CS 103A/B must complete two electives; students who opt for CS 103X must complete three. The list of approved electives is reviewed annually by the CS Undergraduate Program Committee. The current list consists of CS 110, 121 or 221, 137, 140, 143, 145, 147, 148 or 248, 154, 155, 157, 161, 205, 206, 222, 223A, 223B, 224M, 224N, 225A, 225B, 226, 227, 228, 229, 240, 241, 242, 243, 244A, 245, 246, 247A, 247B, 249, 255, 256, 257, 258, 261, 270, 271, 272, 274; EE 212, 216, 247, 264, 278, 282.
- Independent study projects (CS 191, or 191W) require faculty sponsorship and must be approved in advance by the adviser (R.Shackelford), faculty sponsor, and the CSE program adviser. A signed approval form, along with a brief description of the proposed project, should be filed at least two quarters before graduation. Further details can be found in the *Handbook for Undergraduate Engineering Programs* at <http://ughb.stanford.edu>.

PRODUCT DESIGN

Mathematics (20 units minimum):	
Recommended: one course in Statistics	
Science (17 units minimum):	
Recommended: one year of PHYSICS	
PSYCH 1. Introduction to Psychology (required)	4
PSYCH 161. Cultural Psychology (required) ¹	4
Mathematics and Science (minimum combined total of 45 units):	
Technology in Society (one course):	
ME 120. History of Philosophy of Design (required)	
Engineering Fundamentals (18 units minimum):	
ENGR 40, 70 required, plus remainder of course work from ENGR 10, 15, 20, 25 30, 50, 60; MS&E 100, 133	
Engineering Depth (45 units):	
ARTHIST 60. Basic Design	3
ARTHIST 160. Intermediate Design	3
Art Studio courses (two; ARTSTUDI 70 recommended)	6
ENGR 102M	1
ME 80. Stress, Strain, and Strength	3
ME 101. Visual Thinking	3
ME 103D. Engineering Drawing	1
ME 110A. Design Sketching	1
ME 112. Mechanical Systems	4
ME 115. Human Values in Design	3
ME 116. Product Design: Formgiving	4
ME 203. Manufacturing and Design	4
ME 216A. Advanced Product Design	4
ME 216B. Advanced Product Design ²	4
Maximum total units	111

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- One quarter abroad may substitute for this course.
- Combined Product Design/ME students.

INDIVIDUALLY DESIGNED MAJORS (IDMs)

IDMs are 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. IDM 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 with an Individually Designed Major in Engineering: (approved title)."

Students must submit written proposals to the IDM Subcommittee detailing their course of study. Programs must meet the following requirements: mathematics (21 unit minimum, see Basic Requirement 1 below), science (17 units minimum, see Basic Requirement 2 below), Technology in Society (one approved course, see Basic Requirement 4 below), engineering (40 units minimum), and sufficient relevant additional course work to bring the total number of units to at least 90 and at most 107. (Students may take additional courses pertinent to their IDM major, but the IDM proposal itself may not exceed 107 units.) The student's curriculum must include at least three "Engineering Fundamentals" courses (ENGR 10, 14, 15, 20, 25, 30, 40, 50, 60, 62, 70A, and 70X). 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 also specify how the various 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 IDM Subcommittee is listed on the student's official University transcript.

The proposal statement should be followed by a completed Program Sheet listing all the courses comprising the student's IDM curriculum, organized by the five categories printed on the sheet (mathematics, science, Technology in Society, additional courses, 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 which courses will be taken each quarter should also be included in the student's IDM proposal.

The proposal must be signed by two faculty members whose signatures 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 from the School of Engineering, acts as the student's primary adviser. The proposal must be accompanied by a statement from that person giving her or his appraisal of the academic value and viability of the proposed major.

Students proposing IDMs 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 IDM 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. Forms may be obtained from the *Handbook for Undergraduate Engineering Programs*' web site at <http://ughb.stanford.edu>. Completed proposals should be submitted to Bertha Love in the Office of Student Affairs, Terman 201.

DEPARTMENTAL MAJORS

Curricula for majors offered by the departments of Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering, Management Science and Engineering, Materials Science and Engineering, and Mechanical Engineering have the following components: 40-47 units of mathematics and science (see Basic Requirements 1 and 2 at the end of this section); engineering fundamentals (three course minimum, at least one of which must be unspecified by the department, see Basic Requirement 3); Technology in Society (TIS) (one course minimum, see Basic Requirement 4); engineering depth (courses such that the total of units for Engineering Fundamentals and Engineering Depth is between 60 and 75). Curricular requirements for departmental majors were being revised at the time of publication. Consult the 2003-04 *Handbook for Undergraduate Engineering Programs* online at <http://ughb.stanford.edu> for the most up-to-date listing of curricular requirements.

Experimentation—Departmental major programs other than Computer Science must include 8 units of experimentation. Lab courses taken in the sciences, as well as experimental work taken in courses within the School of Engineering, can be used in fulfillment of this requirement. By careful planning, the experimentation requirement should not necessitate additional course work beyond that required to meet the other components of an engineering major. A list of courses and their experimentation content (in units) can be found online at <http://ughb.stanford.edu> in the 2003-04 *Handbook for Undergraduate Engineering Programs*.

CHEMICAL ENGINEERING (CHE)

Course No. and Subject	Units
Mathematics:	
MATH 41, 42	10
ENGR 154. Intro to Engineering Mathematics	5
or MATH 51. Calculus	5
ENGR 155A. Mathematical and Computational Methods for Engineers	5
or MATH 52. Calculus	
and MATH 53. Ordinary Differential Equations	10
ENGR 155B. Mathematical & Computational Methods for Engineers	5
or ENGR 155C. Mathematical & Computational Methods for Engineers	4
Science:	
CHEM 31. Chemical Principles	4
CHEM 33. Structure and Reactivity	4
CHEM 35. Organic Monofunctional Compounds	4
CHEM 36. Chemical Separations	3
PHYSICS 53. Mechanics	4
PHYSICS 55. Electricity and Magnetism	3
Technology in Society (one course required):	
(See Basic Requirement 4)	3-5
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by the department):	
ENGR 20. Introduction to Chemical Engineering	3
ENGR 25. Biotechnology	3
One elective	3-5

Chemical Engineering Depth:	
BIOSCI 41. Genetics and Biochemistry	5
CHEMENG 10. The Chemical Engineering Profession	1
CHEMENG 100. Chemical Process Modeling, Dynamics, & Control	3
CHEMENG 110. Equilibrium Thermodynamics	3
CHEMENG 120A. Fluid Mechanics	4
CHEMENG 120B. Energy and Mass Transport	4
CHEMENG 130. Separation Process	3
CHEMENG 170. Kinetics and Reactor Design	3
CHEMENG 180. Chemical Engineering Plant Design	3
CHEMENG 185A,B. Chemical Engineering Laboratory (WIM)	6
CHEM 131. Organic Polyfunctional Compounds	3
CHEM 132. Qualitative Organic Analysis	5
CHEM 171. Physical Chemistry: Chemical Thermodynamics	3
CHEM 173. Physical Chemistry: Quantum Chemistry	3
CHEM 175. Physical Chemistry	3
Two of:	
CHEMENG 140. Microelectronics Processing Technology	3
CHEMENG 150. Biochemical Engineering	3
CHEMENG 160. Polymer Science and Engineering	3
Total	117-122

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

CIVIL ENGINEERING (CEE)

Mathematics and Science:	
(45 units minimum) ¹	(See Basic Requirements 1 and 2)
Technology in Society (one course):	(See Basic Requirement 4)
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by department): (See Basic Requirement 3)	
ENGR 14. Applied Mechanics: Statics	3
ENGR 60. Engineering Economy	3
Elective Fundamental	3-5
Engineering Depth:	
CEE 70. Environmental Science and Technology	3
CEE 100. Managing Civil Engineering Projects (WIM)	4
CEE 101A. Mechanics of Materials	4
CEE 101B. Mechanics of Fluids	4
CEE 101C. Geotechnical Engineering	4
Specialty courses in either	
Environmental and Water Studies ²	
or Structures and Construction ³	33-40
Other School of Engineering Electives	0-7
Total for Engineering Fundamentals plus Depth	68

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- Mathematics must include ENGR 155A and a Statistics class. Science must include PHYSICS 53, CHEM 31, and GES 1. For students in the Environmental and Water Studies track, CHEM 33 also is required.
- Environmental and Water Studies: ENGR 30; CEE 101D, 160, 161A, 166A, 166B, 171, 172, 177, 179A; and either CEE 169 or 179B. Remaining specialty units from: CEE 63, 64, 164, 169, 173A, 173B, 176A, 176B, 178, 179B, 199.
- Structures and Construction: ENGR 50; CEE 102, 156, 156A, 180, 181, 181A, 182, 182A, and 183. Remaining specialty units from: ENGR 15, 155B; CEE 101D, 111, 114, 122A/B, 140, 143, 147, 148, 154, 155, 160, 161A, 171, 176A, 176B, 195, 196, 199, 203, and one of 130, 131, 134, or 138.

COMPUTER SCIENCE (CS)

Mathematics (25 units minimum):	
CS 103X. Discrete Structures (Accelerated)	
or CS 103A and 103B	4-6
MATH 41, 42. Calculus ¹	10
STATS 116. Theory of Probability	5
or MS&E 120. Problem Analysis	
Plus any two of the following:	
CS 157. Logic (or PHIL 160A)	4
CS 205. Math for Robotics and Vision	3
MATH 51. Calculus	5
MATH 103 or 113. Linear Algebra ²	3
MATH 109. Applied Modern Algebra	3
Science (11 unit):	
PHYSICS 53. Mechanics	4
PHYSICS 55. Electricity and Magnetism	4
Science Elective ³	3
Technology in Society (one course, 3-5 units) (See Basic Requirement 4)	
Engineering Fundamentals (13 units):	
CS 106X. Programming Methodology and Abstractions (Accelerated)	
or CS 106A and 106B	5
ENGR 40. Electronics	5
Elective ⁴	
Writing in the Major (one course):	
CS 191W, 194, and 201 fulfill this requirement	
Computer Science Depth (43 units minimum):	
Programming (two courses):	

CS 107. Programming Paradigms	5
CS 108. Object-Oriented Systems Design	4
Theory (two courses):	
CS 154. Introduction to Automata and Complexity Theory	4
CS 161. Design and Analysis of Algorithms	4
Systems (three courses):	
EE 108B. Digital Systems II	4
Two systems electives ⁵	7-8
Applications (two courses):	
CS 121 or 221. Introduction to Artificial Intelligence	3-4
One applications elective ⁶	3-4
Project (one course):	
CS 191, 191W, or 194 ⁷	3
Restricted Electives (two or three courses) ⁸	6-12

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- MATH 19, 20, and 21 may be taken instead of MATH 41 and 42 as long as at least 25 math units are taken.
- Completion of MATH 52 and 53 satisfies the MATH 103/113 requirement.
- The science elective may be any course of 3 or more units from the School of Engineering lists plus PSYCH 30 or 40; AP Biology or Chemistry also meets this requirement. Either of the PHYSICS sequences 61/63 or 21/23 may be substituted for 53/55 as long as at least 11 science units are taken.
- One course required, 3 to 5 units. See list in the *Handbook for Undergraduate Engineering Programs* at <http://ughb.stanford.edu>.
- The two systems courses must be chosen from the following set: CS 140, 143, 242, and 244A. The systems electives must include a course with a large software project, currently satisfied by either CS 140 or 143.
- The applications elective must be chosen from the following set: CS 145, 147, 148, 223A, 223B, or 248.
- Independent study projects (CS 191 or 191W) require faculty sponsorship and must be approved by the adviser, faculty sponsor, and the CS program adviser (R. Shackelford). A signed approval form, along with a brief description of the proposed project, should be filed at least two quarters before graduation. Further details can be found in the *Handbook for Undergraduate Engineering Programs*.
- Students who take CS 103A,B must complete two electives; students who opt for 103X must complete three. The list of approved electives is reviewed annually by the Undergraduate Program Committee. The current list consists of CS 110, 137, 140, 143, 145, 147, 148 or 248, 155, 157, 205, 206, 222, 223A, 223B, 224M, 224N, 225A, 225B, 226, 227, 228, 229, 240, 241, 242, 243, 244A, 245, 246, 247A, 247B, 249, 255, 256, 257, 258, 261, 270, 271, 272, 274; and EE 282.

ELECTRICAL ENGINEERING (EE)

Mathematics:	
MATH 41, 42, 51, 52, 53	25
EE 178, STATS 116, MATH 151, or ENGR 155C	3-5
Science:	
PHYSICS (51, 53, 55) or (61, 63, 65)	12
Math or Science Electives:	3-4
Total Math and Science Units	45
Technology in Society (one course):	3
Technical Writing: ENGR 102E (WIM corequisite for EE 108A)	1
The Electrical Engineering Profession	1
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by department):	
CS 106X or CS 106B	5
ENGR 40	5
One additional course not in EE or CS	3-5
Engineering Depth:	
Electronics: EE 101A,B	8
Signals and Systems: EE 102A,B	8
Digital Systems: EE 108A (Laboratory, WIM), 108B	8
Analog Laboratory: 122	3
Fields and Waves: EE 41 or EE 141	4
Specialty courses ¹	9-12
One course in Design ²	
Electrical Engineering electives	10-15
Total Engineering Topics (Fundamentals and depth) required	68

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- Three courses from one of the specialty areas shown below (consultation with an adviser in the selection of these courses is especially important):
 - Computer Hardware: EE 184 (CS 107), 281 (271 or 275), 273
 - Computer Software: EE 184 (CS 107), 189A (CS 108), 189B (CS 194) (284 or CS 244A)
 - Controls: EE 105 (ENGR 105), EE 205 (ENGR 205), EE 206 (ENGR 206), EE 209A (ENGR 209A), EE 209B (ENGR 209B)
 - Electronics: EE 116, 133, 212, 214, 216
 - Fields and Waves: EE 142, 144, 241, 247
 - Communications and Signal Processing: EE 133, 168, 179, 261 (264 or 265), 278, 279
- The design course may, but need not, be part of the specialty sequence. The following courses satisfy this requirement: EE 118, 189B (CS 194), 133, 144, 281; ENGR 206.

ENVIRONMENTAL ENGINEERING (in CEE)

Mathematics and Science:	
45 unit minimum ¹	(See Basic Requirement 1 and 2)

Technology in Society ² (one course):	(See Basic Requirement 4)
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by department):	(See Basic Requirement 3)
ENGR 30. Engineering Thermodynamics	3
ENGR 60. Engineering Economy	3
Elective Fundamental	3-5
Engineering Depth:	
CEE 64. Air Pollution: From Urban Smog to Global Change	3
CEE 70. Environmental Science and Technology	3
CEE 100. Managing Civil Engineering Projects (WIM)	4
CEE 101B. Mechanics of Fluids	4
CEE 101D. MathLab Applications in CEE	2
CEE 160. Mechanics of Fluids Laboratory	2
CEE 161A. Rivers, Streams, and Canals	3
CEE 166A. Watersheds and Wetlands	3
CEE 166B. Floods and Droughts, Dams, and Aqueducts	3
CEE 171. Environmental Planning Methods	3
CEE 172. Air Quality Management	3
CEE 177. Aquatic Chemistry and Biology	4
CEE 179A. Aquatic Chemistry Laboratory	2
Capstone design experience (either CEE 169 or 179B)	5
CEE Breadth Electives ³	10
Other School of Engineering Electives	2-9
Total for Engineering Fundamentals plus Depth	68

These requirements are subject to change. The final requirements are published along with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- Math must include, ENGR 155A, and a Statistics class. Science must include PHYSICS 53; CHEM 31, 33; and GES 1.
- Should choose a class that specifically includes an ethics component, such as STS 101, 110, 115, 170, or 215.
- Breadth electives currently include CEE 63, 101C, 164, 169, 173A, 173B, 176A, 176B, 178, 179B, and 199.

MANAGEMENT SCIENCE AND ENGINEERING (MS&E)

Mathematics (28 units minimum ¹):	(See Basic Requirement 1)
MATH 41. Calculus	5
MATH 42. Calculus	5
MATH 51. Calculus	5
STATS 110. Statistical Methods	4-5
MS&E 120. Probabilistic Analysis	5
MS&E 121. Introduction to Stochastic Modeling	4
Science (14 units minimum ¹):	(See Basic Requirement 2)
One of the following Physics sequences:	
PHYSICS 53, 55, and 56	8
PHYSICS 21, 23, and 22 or 24	7
CHEM 31. Chemical Principles	4
Technology in Society (one course ²):	(See Basic Requirement 4)
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by department):	(See Basic Requirement 3)
ENGR 40. Introductory Electronics	5
Two other engineering fundamentals from School of Engineering approved list (ENGR 25 is recommended) ⁴	6-10
Engineering Depth (CORE):	27-30
CS 106A. Programming Methodology ⁵	5
CS 106B or 106X. Programming Abstractions	5
ENGR 60. Engineering Economy	3
ENGR 62. Introduction to Optimization	4
MS&E 108 or 131. Senior Project or Information Science	3-5
MS&E 180. Organizations: Theory and Management	4
MS&E 242 or 245G or 247G. Investment Science/Introduction to Finance ³	3-4
Engineering Depth (Concentration: choose one of the following concentrations):	23-30
Industrial Engineering/Operations Management Concentration ⁶	27-29
MS&E 130. Information Systems	4
MS&E 140. Industrial Accounting	4
MS&E 160. Analysis of Production and Operating Systems	4
MS&E 164. Manufacturing Systems Design (WIM)	5
MS&E 169. Quality Assurance and Control	4
Two electives from MS&E approved list ⁷	6-8
Financial and Decision Engineering Concentration:	27-29
ECON 50. Economic Analysis I	5
ECON 51. Economic Analysis II	5
MS&E 140. Industrial Accounting	4
MS&E 152. Introduction to Decision Analysis (WIM)	4
MS&E 242. Investment Science ³	3
One of the following three courses:	
MS&E 107. Interactive Management Science	3
MS&E 221. Stochastic Modeling	3
MS&E 223. Stimulation	3
One of the following three courses:	
ECON 52. Economic Analysis III	5
ENGR 145. Introduction to High Technology	

Entrepreneurship	3
MS&E 250A. Engineering Risk Analysis	3
Operations Research Concentration:	26-29
ECON 50. Economic Analysis	5
MATH 53. Ordinary Differential Equations with Linear Algebra ³	5
Four of the following eight courses:	
MS&E 107. Interactive Management Science	3
MS&E 112. Network Integer Programming	3
MS&E 152. Introduction to Decision Analysis	4
MS&E 201. Dynamic Systems	4
MS&E 211. Linear and Nonlinear Optimization	4
MS&E 221. Stochastic Modeling	3
MS&E 223. Simulation	3
MS&E 251. Stochastic Decision Models	3
One of the following three courses:	
CS 109. Introduction to Computer Science	4
CS 137. Introduction to Scientific Computing	4
MS&E 130. Information Systems	4
Technology and Organizations Concentration:	23-27
Six of the following eleven courses	
ENGR 131. Ethical Issues in Engineering ³	4
ENGR 145. Introduction to High Tech. Entrepreneurship	3
MS&E 130. Information Systems	4
MS&E 134. Organization and Info Systems	3-4
MS&E 164. Manufacturing Systems Design (WIM)	5
MS&E 181. Issues in Technology and Work in Post-Industrial Economics ³	4
MS&E 182. Work, Technology, and Society	4
MS&E 267. Innovations Manufacturing	4
MS&E 284. Technology and Work	4
PSYCH 70. Introduction to Social Psychology ³	4
SOC 160. Formal Organizations	5
Technology and Policy Concentration:	24-30
ECON 50. Economic Analysis I	5
ECON 51. Economic Analysis II	5
ECON 150/PUBLPOL 104. Economics and Public Policy	5
One of the following three courses:	
MS&E 197. Ethics and Public Policy (WIM) ³	5
POLISCI 122. Introduction to American Law	3-5
One of the following eight courses:	
CEE 171. Environmental Planning Methods	3
COMM 137. Telecommunication Policy and the Internet	4-5
EARTHSYS 167. Ocean Policy: Marine Stewardship and the Law	4
ECON 155. Environmental Economics and Policy	5
MS&E 193. Role of Technology and Nation Security (WIM) ⁵	3
MS&E 195. International Security in a Changing World	5
MS&E 196. Transportation Systems and Urban Development	3
POLISCI 118S. International Environmental Politics	5
One of the following six courses:	
CEE 265B. Environmental Policy Design and Implementation ⁴	4
ECON 158. Antitrust and Regulation	5
MS&E 237. Progress in Worldwide Telecommunications (Summer only)	3
MS&E 290. Public Policy Analysis	3
MS&E 298. Technology Policy and Management in Newly Developed Countries ³	3-4
PUBLPOL 194. Technology Policy	5

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- Math and Science must total 45 units. Electives must come from the School of Engineering approved list, or PHYSICS 21, 22, 23, 24, 25, 26, PSYCH 40, or PSYCH 70. AP credit for Biology, Chemistry, Mathematics, Physics, and Statistics may also be used.
- Technology in Society course must be one of the following MS&E approved courses: STS 101/ENGR 130, STS 110/MS&E 197 (WIM), STS 115/ENGR 131, STS 135/MS&E 181, STS 162, STS 170/MS&E 182, STS 171/MS&E 193 (WIM), STS 215, STS 279/MS&E 298.
- Courses used to satisfy the Math, Science, TIS, or Engineering depth requirement may not also be used to satisfy a depth requirement.
- Students may not count CS 106A, ENGR 60, or ENGR 62 for Engineering Fundamentals, as those courses count toward Engineering Depth.
- AP credit for CS may be used.
- Students completing the Industrial Engineering/Operations Management Concentration with the project course can choose to receive an Industrial Engineering degree from the Management Science and Engineering Department.
- Students choosing the Industrial Engineering/Operations Management Concentration must choose two of the following MS&E approved electives: CEE 100, 146, 241; CHEM-ENG 160; CS 147; ENGR 1, 145; MS&E 107, 112, 134, 152 (WIM), 181, 182, 247G, 250A, 262, 265, 267, 464; ME 103 and 103D.

MATERIALS SCIENCE AND ENGINEERING (MATSCI)

Mathematics (20 units minimum):	(See Basic Requirement 1)
Science (20 units minimum):	(See Basic Requirement 2)
Technology in Society (one course):	(See Basic Requirement 4)
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by department):	(See Basic Requirement 3)

Engineering Depth:	
MATSCI 151. Microstructure and Mechanical Properties	3
MATSCI 152. Electronic Materials Engineering	3
MATSCI 161. Materials Science Lab I	4
MATSCI 162. Materials Science Lab II (WIM)	4
MATSCI 163. Materials Science Lab III	4
Materials Science Fundamentals, ¹ ME 24 Science and Engineering Options ²	9
Total	51

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- MATSCI Fundamentals; 24 units from MATSCI 190, 191, 192, 193, 194, 195, 196, 197, 198, 199
- MATSCI Options; 9 units from one of the following six areas:
 - Chemistry (CHEM 151, 153, 171, 173, 175)
 - Chemical Engineering (CHEMENG 110, 130, 140, 150, 170; ENGR 20; ME 70)
 - Electrical Engineering (EE 101, 102, 111, 112, 113, 141, 142; ENGR 40)
 - Mechanical Engineering (ENGR 14, 15; ME 70, 80, 131A, 131B, 161, 203)
 - Physics (PHYSICS 110,, 120, 121, 124, 130, 131, 134 170, 171, 172)
 - Self-Defined Option (petition for a self-defined cohesive program, minimum of 9 units)

MECHANICAL ENGINEERING (ME)

Mathematics (24 units minimum ¹):	(See Basic Requirement 1)
Science (18 units minimum ¹):	(See Basic Requirement 2)
Technology in Society (one course):	(See Basic Requirement 4)
Engineering Fundamentals (three courses minimum, at least one of which must be unspecified by the department):	(See Basic Requirement 3)
Engineering Depth:	
ENGR 14. Applied Mechanics: Statics and Deformables	3
ENGR 15. Dynamics	3
ENGR 102M. Technical Writing (WIM corequisite for ME 203)	1
ME 70. Introductory Fluids Engineering	4
ME 80. Stress, Strain, and Strength	3
ME 101. Visual Thinking	3
ME 103D. Engineering Drawing	1
ME 112. Mechanical Systems Design	4
ME 113. Engineering Design	3
ME 131A. Heat Transfer	4
ME 131B. Fluid Mechanics	3
ME 140. Advanced Thermal Systems	4
ME 161. Mechanical Vibrations	4
ME 203. Manufacturing and Design (WIM)	4
Total	42

Options to complete the ME Depth sequence (pick three items below):

ENGR 105A. Control Systems	3
ME 150. Internal Combustion Engines	3
ME 210. Introduction to Mechatronics	4
ME 220. Introduction to Sensors	3
ME 227. Vehicle Dynamics and Control	3
ME 280. Skeletal Development and Evolution	3
ME 281. Biomechanics of Movement	3

These requirements are subject to change. The final requirements are published with example programs in the *School of Engineering Undergraduate Handbook* during the summer.

- Math and science must total 45 units. Math: 24 units required and must include a course in differential equations (e.g., ME 155A). Science: 18 units minimum and must include chemistry and physics, with at least one year's study in one of them.

BASIC REQUIREMENTS

Basic Requirement 1 (Mathematics)—Engineering students need a solid foundation in the calculus of continuous functions including differential equations, an introduction to discrete mathematics, and an understanding of statistics and probability theory. The minimum preparation should normally include calculus to the level of MATH 53. Knowledge of ordinary differential equations and matrices is important in many areas of engineering, and students are encouraged to select additional courses in these topics. To meet ABET accreditation criteria, a student's program must include the study of differential equations.

Courses that satisfy the mathematics requirement are listed online at <http://ughb.stanford.edu> in the *Handbook for Undergraduate Engineering Programs*.

Basic Requirement 2 (Science)—A strong background in the basic concepts and principles of natural science in such fields as biology, chemistry, geology, and physics is essential for engineering. Most students include the study of physics and chemistry in their programs.

Courses that satisfy the science requirement are listed online at <http://ughb.stanford.edu> and in the *Handbook for Undergraduate Engineering Programs*.

Basic Requirement 3 (Engineering Fundamentals)—The Engineering Fundamentals requirement is satisfied by a nucleus of technically rigorous introductory courses chosen from the various engineering disciplines. It is intended to serve several purposes. First, it provides students with a breadth of knowledge concerning the major fields of endeavor within engineering. Second, it allows the incoming engineering student an opportunity to explore a number of courses before embarking on a specific academic major. Third, the individual classes each offer a reasonably deep insight into a contemporary technological subject for the interested non-engineer.

The requirement is met by taking three courses from the following list, at least one of which must be unspecified by the department):

ENGR 10. Introduction to Engineering Analysis
 ENGR 14. Applied Mechanics: Statics and Deformables
 ENGR 15. Dynamics
 ENGR 20. Introduction to Chemical Engineering
 ENGR 25. Biotechnology
 ENGR 30. Engineering Thermodynamics
 ENGR 40. Introductory Electronics¹
 ENGR 50. Introductory Science of Materials¹
 ENGR 60. Engineering Economics
 ENGR 62. Introduction to Optimization
 ENGR 70A or 70X. Introduction to Software Engineering

¹ ENGR 40 and 50 may be taken on video at some of Stanford's Overseas Centers.

Basic Requirement 4 (Technology in Society)—It is important for the student to obtain a broad understanding of engineering as a social activity. To foster this aspect of intellectual and professional development, all engineering majors must take one course devoted to exploring issues arising from the interplay of engineering, technology, and society. Courses that fulfill this requirement are listed online at <http://ughb.stanford.edu> and in the *Handbook for Undergraduate Engineering Programs*.

MINORS

An undergraduate minor in Engineering may be pursued by interested students in many of the school's departments; consult with a department's undergraduate program representative, or the Office of Student Affairs, Terman Engineering Center, room 201. General requirements and policies for a minor in the School of Engineering are: (1) a set of courses totaling not less than 18 and not more than 36 units, with a minimum of six courses of at least 3 units each; (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) departmentally based minor programs are structured at the discretion of the sponsoring department, subject only to requirements 1, 2, and 3 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)

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

The following core courses fulfill the minor requirements:

Course No. and Subject	Units
AA 100. Introduction to Aeronautics and Astronautics	3
ENGR 14. Statics ¹	3
ENGR 15. Dynamics ¹	3
ENGR 30. Thermodynamics ¹	3
ME 70. Introductory Fluids	4
ME 131A. Heat Transfer	4
Core Total	20

¹ ENGR 14, 15, or 30 are waived as minor requirements if already taken as part of the major.

The following courses are upper-division electives.

Two courses from one of the elective areas below	6
One course from a second area	3
Program Total	20-33
Aerospace Systems Synthesis/Design:	
AA 236A,B. Spacecraft Design	6
AA 241A,B. Aircraft Design	6
Dynamics and Controls:	
AA 242A. Classical Dynamics	3
AA 271. Dynamics and Control of Spacecraft/Aircraft	3
AA 279. Space Mechanics	3
ENGR 105. Feedback Control Design	3
ENGR 205. Introduction to Control Design Techniques	3
Fluids:	
AA 200A. Applied Aerodynamics	3
AA 210A. Fund of Compressible Flow	3
AA 214A. Numerical Methods in Fluid Mechanics	3
or AA 283. Aircraft Propulsion	3
Structures:	
AA 240A. Analysis of Structures	3
AA 240B. Analysis of Structure II	3
AA 256. Mechanics of Composites	3

CHEMICAL ENGINEERING

The following courses fulfill the minor requirements:

CHEMENG 100. Chemical Process Modeling, Dynamics, and Control	3
CHEMENG 110. Equilibrium Thermodynamics	3
CHEMENG 120A. Fluid Mechanics	4
CHEMENG 120B. Energy and Mass Transport	4
CHEMENG 140. Microelectronics Processing Technology	
or CHEMENG 150. Biochemical Engineering	
or CHEMENG 160. Polymer Science and Engineering	3
CHEMENG 170. Kinetics and Reactor Design	3
CHEMENG 180. Chemical Engineering Plant Design	3
CHEMENG 185A. Chemical Engineering Lab	3
CHEM 171. Physical Chemistry	3
ENGR 20. Introduction to Chemical Engineering	3
Total	32

CIVIL ENGINEERING (CEE)

The Civil Engineering minor is intended to give students an in-depth introduction to one or more areas of civil engineering. Departmental expertise and undergraduate course offerings are available in the areas of Construction Engineering, and Management, Structural Engineering, and Architectural Engineering. The minimum prerequisite for a Civil Engineering minor is MATH 42 (or 21); however, many courses of interest require PHYSICS 53 and/or MATH 51 as prerequisites. Students should recognize that a minor in Civil Engineering is *not* an ABET-accredited degree program.

Since civil engineering is a very broad field and undergraduates with widely varying backgrounds may be interested in obtaining a civil engineering minor, no single set of course requirements is appropriate for all students. Instead, interested students are encouraged to propose their own set of courses within the guidelines listed below; this list must be officially approved by the Civil and Environmental Engineering (CEE) undergraduate minor adviser. Additional information on preparing a minor program, including "example" programs focusing on each of the areas of expertise listed above is available in the CEE office (Terman M-2). While each example program focuses on a different area of expertise within the department, other combinations of courses are also possible.

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.
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.
3. Professor Street (524-524R; 723-4969; street@stanford.edu) is the CEE undergraduate minor adviser, and provides guidance and advice. Students must consult with Professor Street in developing their minor program, and obtain approval of the finalized study list from him.

COMPUTER SCIENCE (CS)

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

Introductory Programming:

CS 106A,B. Programming Method/Abstractions	10
or CS 106X. Programming Method/Abstractions (Accelerated)	5
(AP Credit may be used to fulfill this requirement)	
Core:	
CS 103A/B. Discrete Math/Structures	6
or CS 103X. Discrete Structures	4
CS 107. Programming Paradigms	5
CS 108. Object-Oriented Systems Design	4
Electives: select two courses from different areas	
Artificial Intelligence:	
CS 121. Introduction to Artificial Intelligence	3
CS 221. AI: Principles and Techniques	4
Human-Computer Interaction:	
CS 147. Introduction to Human-Computer Interaction Design	3-4
Numerical Computing:	
CS 137. Introduction to Scientific Computing	4
Systems:	
CS 140. Operating Systems	4
CS 143. Compilers	4
CS 145. Databases	4
CS 148. Graphics	3
Theory:	
CS 154. Automata and Complexity Theory	4
CS 157. Logic and Automated Reasoning	4
CS 161. Design and Analysis of Algorithms	4

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

ELECTRICAL ENGINEERING (EE)

Courses fulfilling the minor are from any of the following three tracks:

Option I:	
ENGR 40. Introductory Electronics	5
EE 101A. Circuits I	4
EE 101B. Circuits II	4
EE 102A. Signal Processing and Linear Systems I	4
Four graded EE courses of level 100 or higher	
Option II:	
ENGR 40. Introductory Electronics	5
EE 101A. Circuits I	4
EE 116. Semiconductor Device Physics	3
EE 122. Analog Circuits Laboratory	3
Four graded EE courses of level 100 or higher	
Option III:	
ENGR 40. Introductory Electronics	5
EE 108A. Digital Systems I	4
EE 181. Introduction to Computer Systems and Assembly Language Programming (enroll in CS 110)	4
EE 182. Computer Organization and Design	4
Four graded EE courses of level 100 or higher	

ENVIRONMENTAL ENGINEERING

The Environmental Engineering minor is intended to give students a broad introduction to one or more areas of Environmental Engineering. Departmental expertise and undergraduate course offerings are available in the areas of Environmental Engineering and Science, Environmental Fluid Mechanics and Hydrology, and Energy Engineering. The minimum prerequisite for an Environmental Engineering minor is MATH 42 (or 21); however, many courses of interest require PHYSICS 53 and/or MATH 51 as prerequisites. Students should recognize that a minor in Environmental Engineering is not an ABET-accredited degree program.

Since undergraduates having widely varying backgrounds may be interested in obtaining an environmental engineering minor, no single set of course requirements is appropriate for all students. Instead, interested students are encouraged to propose their own set of courses within the guidelines listed below; this list must be officially approved by the Civil and Environmental Engineering (CEE) undergraduate minor adviser. Additional information on preparing a minor program, including "example" programs focusing on each of the areas of expertise listed above, is available in the CEE office (Terman M-42). While each example program focuses on a different area of expertise within the department, other combinations of courses are also possible.

General guidelines are:

1. An Environmental 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.

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.
3. Professor Street (524-524R; 723-4969; street@stanford.edu) is the CEE undergraduate minor adviser, and provides guidance and advice. Students must consult with Professor Street in developing their minor program, and obtain approval of the finalized study list from him.

MANAGEMENT SCIENCE AND ENGINEERING (MS&E)

The following courses fulfill the minor requirements:

Background requirements:	
MATH 51. Calculus	
Minor requirements:	
ENGR 60. Engineering Economy (prerequisite: MATH 41)	3
ENGR 62. Introduction to Optimization	4
MS&E 120. Probabilistic Analysis (prerequisite: MATH 51)	5
MS&E 121. Introduction to Stochastic Modeling	4
One of the following three courses:	
MS&E 180. Organizations: Theory and Management	4
MS&E 181. Issues in Technology and Work in Post-Industrial Economy	3
MS&E 182. Work, Technology, and Society	4
One of the following two courses:	
MS&E 242. Investment Science	3
MS&E 245G. Introduction to Finance	4
Electives (Any two 100 or 200 level MS&E courses)	

MATERIALS SCIENCE AND ENGINEERING (MATSCI)

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:

Fundamentals:	
ENGR 50. Introductory Science of Materials	4
MATSCI 151. Microstructure and Mechanical Properties	3
MATSCI 152. Electronic Materials Engineering	3
Electives (four courses from the MS&E Core, 16 units):	
MATSCI 190. Organic Materials	4
MATSCI 191. Mathematical and Computational Methods in Materials Science	4
MATSCI 192. Solid State Thermodynamics	4
MATSCI 193. Atomic Arrangements in Solids	4
MATSCI 194. Phase Equilibria and Thermodynamics	4
MATSCI 195. Waves and Diffraction in Solids	4
MATSCI 196. Imperfections in Crystalline Solids	4
MATSCI 197. Rate Processes in Materials	4
MATSCI 198. Mechanical Properties of Materials	4
MATSCI 199. Electrical, Optical, and Magnetic Properties of Solids	4

MECHANICAL ENGINEERING (ME)

The following courses fulfill the minor requirements:

General Minor—This minor aims to expose students to the breadth of ME in terms of topics and of analytic and design activities. The minor consists of seven courses totaling 26 to 28 units. Prerequisites are MATH 41, 42; PHYSICS 53.

ENGR 14. Applied Mechanics: Statics	3
ENGR 15. Dynamics	4
ENGR 30. Engineering of Thermodynamics	3
ME 70. Introductory Fluids Engineering	4
ME 101. Visual Thinking	3

Plus two of the following:

ME 80. Stress, Strain, and Strength	3
ME 131A. Heat Transfer	4
ME 161. Dynamic Systems	4
ME 203. Manufacturing and Design	4

Thermosciences—This minor consists of seven courses totaling 26 units. Prerequisites are MATH 41, 42, 43; PHYSICS 53.

ENGR 14. Applied Mechanics: Statics	3
ENGR 30. Engineering Thermodynamics	3
ME 70. Introductory Fluids Engineering	4
ME 131A. Heat Transfer	4
ME 131B. Fluid Mechanics	3
ME 140. Advanced Thermal Systems	3

Mechanical Design—This minor aims to expose students to design activities, supported by analysis. This proposed minor consists of seven courses totaling 24 to 26 units. Prerequisites are MATH 41, 42; PHYSICS 53.

ENGR 14. Applied Mechanics: Statics	3
ENGR 15. Dynamics	3
ME 80. Stress, Strain, and Strength	3
ME 112. Mechanical Systems	4
Plus two of the following:	
ME 99. Mechanical Dissection	3
ME 101. Visual Thinking	3
ME 203. Manufacturing and Design	4
Plus one of the following:	
ME 113. Engineering Design	3
ME 220. Introduction to Sensors	3
ME 210. Introduction to Mechatronics	4

GRADUATE PROGRAMS

ADMISSION

Application for admission with graduate standing in the school should be made to the department's graduate admissions committee. 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.

Fellowships and Assistantships—Departments and divisions of the School of Engineering award graduate fellowships, research assistantships, and teaching assistantships each year. Information and application forms may be obtained from the chair of the appropriate department or division.

Registration—New graduate students should follow procedures for registration as listed in the University's quarterly *Time Schedule*. Adviser assignments can be obtained from department offices.

THE HONORS COOPERATIVE PROGRAM

A number of industrial firms, government laboratories, and other organizations participate in the Honors Cooperative Program (HCP), a program that permits qualified engineers, scientists, and technology professionals to register for Stanford courses and obtain a graduated degree on a part-time basis.

The courses are offered by the School of Engineering on campus or through the Stanford Center for Professional Development (SCPD). SCPD offers more than 200 courses a year delivered in a variety of formats, including microwave broadcast, Internet, videotape, as well as on campus. For industry students not part of the HCP, courses are also available on a Non-Degree Option, Audit Option, certificate, or short course basis and may be customized to meet a company's needs. For a full description of educational services provided by SCPD, call (650) 725-3000; fax (650) 725-2868, write Durand Building., Room 300, Stanford, CA 94305-4036; email scpd-registration@stanford.edu, or visit <http://scpd.stanford.edu>.

ENGINEERING BIOLOGY AND MEDICINE

Stanford does not have a formal department of bioengineering; however, there are several faculty in the School of Engineering whose primary research activities are in this general area. There are many opportunities in the medical and biological sciences for collaboration. Individually designed B.S. majors in bioengineering can be arranged. The faculty working in bioengineering are in various departments of the School of Engineering; a list of their names, together with a summary of their research interests, is available from the committee chair.

Students interested in pursuing graduate study in bioengineering apply for admission and financial aid to the appropriate department on the grounds of their previous training and future interests. Their applications are judged on substantially the same ground as other applicants to the department.

In addition to the standard engineering department degrees, the degree of MSE: Biomechanical Engineering is offered. Details on this program and subsequent Ph.D. studies can be obtained from the Biomechanical Engineering Division, Department of Mechanical Engineering.

The research being conducted in the field of bioengineering within the various departments reflects the technological emphasis of those departments. For instance, research on factors that influence growth and product formation in genetically engineered mammalian cells, immobi-

lized microbial cell function and physiology in compact bioreactors, protein absorption from sheared suspensions onto polymer films, and protein conformation at fluid/polymer interfaces is pursued in the Department of Chemical Engineering. Faculty in Mechanical Engineering are doing research on aids for the disabled, bone mechanics, the mechanics of hearing, neuromuscular dynamics, orthopedic biomechanics, and rehabilitation engineering. Cardiovascular dynamics and hemodynamics are being studied in Computer Science. In Electrical Engineering, advanced analysis techniques are applied to signal processing EKG, EEG, and x-ray image. Many research projects are carried out in collaboration with faculty of the Medical School or members of the local medical community.

Both the master's and the Ph.D. degrees are ordinarily awarded by a particular department, and the candidate must meet the degree requirements of that department. The student's adviser assists in constructing a program of study incorporating appropriate courses in biology and medicine that also satisfy the degree requirements of the department in which the student is registered.

A student wishing to earn the M.S. in Engineering while pursuing the M.D. degree must apply separately for admission to the M.D. program and an engineering department. If the student is admitted to both, each school will encourage his or her pursuit of the other degree.

In addition to the financial support available through the departments in the form of fellowships, research assistantships, and teaching assistantships, there are externally administered fellowship programs for the support of graduate study in health-related fields. In particular, both the National Institutes of Health and the National Science Foundation offer such fellowships based on national competition.

MANUFACTURING

Programs in manufacturing are available at the undergraduate, master's, and Ph.D. level. Master's programs are offered by the departments of Civil and Environmental Engineering, Management Science and Engineering (MS&E), and Mechanical Engineering. The Construction Engineering and Management program, offered by the Department of Civil and Environmental Engineering, is also a "manufacturing" program for students interested in facility and public works manufacturing. All of these programs take advantage of modern computer technology.

Doctoral programs related to manufacturing are available in a number of departments and involve research projects ranging from machine tool design to the integration of databases into production software.

For detailed information about the master's and Ph.D. programs, see the sections of this bulletin pertaining to management science, mechanical, and civil and environmental engineering. For more information on manufacturing research and education in Engineering, browse the AIM web pages at <http://www-sima.stanford.edu/> and the web pages for departments.

CURRICULA

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 select 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 properties of materials, and a student interested in an aspect of materials engineering can often gain appreciable benefit from the related courses given by departments other than her or his own.

Departments and divisions of the school offer graduate curricula as follows.

AERONAUTICS AND ASTRONAUTICS

The current research and teaching activities cover a number of advanced fields, with special emphasis on:

Active Noise Control
Aerodynamic Noise

Aeroelasticity
 Aircraft Design, Performance, and Control
 Applied Aerodynamics
 Biomedical Mechanics
 Computational Aero-Acoustics
 Computational Fluid Dynamics
 Control of Robots, including Space and Deep-Underwater Robots
 Conventional and Composite Structures/Materials
 Direct and Large Eddy Simulation of Turbulence
 Distributed Control of Networks
 High-Lift Aerodynamics
 Hybrid Propulsion
 Hypersonic and Supersonic Flow
 Inertial Instruments
 Multidisciplinary Design Optimization
 Navigation Systems (especially GPS)
 Networked and Hybrid Control
 Optimal Control, Estimation, System Identification
 Physical Gas Dynamics
 Spacecraft Design and Satellite Engineering
 Turbulent Flow and Combustion

CHEMICAL ENGINEERING

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

CIVIL AND ENVIRONMENTAL ENGINEERING

Construction Engineering and Management
 Design/Construction Integration
 Environmental and Water Studies

- Environmental Engineering and Science
- Environmental Fluid Mechanics and Hydrology

 Structural Engineering and Geomechanics

- Geomechanics
- Structural Engineering

COMPUTER SCIENCE

Analysis of Algorithms
 Artificial Intelligence
 Automated Deduction
 Autonomous Agents
 Biomedical Computation
 Compilers
 Complexity Theory
 Computational Biology
 Computational Geometry
 Computational Physics
 Computer Architecture
 Computer Graphics
 Computer Logic
 Computer Security
 Computer Vision

Database Systems
 Design Automation
 Digital Libraries
 Distributed and Parallel Computation
 Formal Verification
 Haptic Display of Virtual Environments
 Human-Computer Interaction
 Image Processing
 Knowledge-Based and Expert Systems
 Knowledge Representation and Logic
 Machine Learning
 Mathematical Theory of Computation
 Multi-Agent Systems
 Natural Language Processing
 Networks, Internet Infrastructure, and Distributed Systems
 Operating Systems
 Programming Systems/Languages
 Reasoning Under Uncertainty
 Robotics
 Scientific Computing and Numerical Analysis
 Ubiquitous and Pervasive Computing

ELECTRICAL ENGINEERING

Computer Hardware
 Computer Software Systems
 Control and Systems Engineering
 Communication Systems
 Electronic Circuits
 Electronic Devices, Sensors, and Technology
 Fields, Waves, and Radioscience
 Lasers, Optoelectronics, and Quantum Electronics
 Network Systems
 Image Systems
 Signal Processing
 Solid State Materials and Devices
 VLSI Design

ENGINEERING

Interdepartmental Programs
 Interdisciplinary Programs

ENGINEERING IN BIOLOGY AND MEDICINE

Biostatistics
 Design for Medical Applications
 Information Processing in and for Biomedical Systems
 Mechanics of Hearing
 Medical Imaging
 Neuromuscular Biomechanics
 Orthopedic Biomechanics
 Rehabilitation Engineering
 Transport Phenomena in Biological Systems

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
 Design/Manufacturing
 Electrical and Optical Behavior of Solids
 Electron Microscopy
 Fracture and Fatigue
 Imperfections in Crystals
 Kinetics
 Magnetic Behavior of Solids
 Magnetic Storage Materials
 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

SCIENTIFIC COMPUTING AND COMPUTATIONAL MATHEMATICS

See the “Scientific Computing and Computational Mathematics” section of this bulletin.

SPACE SCIENCE

See the “Center for Space Science and Astrophysics” section of this bulletin.

MASTER OF SCIENCE

The M.S. degree is conferred on graduate students in engineering according to the University regulations stated in the “Graduate Degrees” 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. However, the presentation of a thesis is not a school requirement.

MASTER OF SCIENCE IN ENGINEERING

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

There are three school requirements for the M.S. degree in Engineering: (1) the student’s program must be a coherent one with a well-defined

objective and must be approved by a department within the school; (2) the student’s program must include at least 21 unit of courses within the School of Engineering with numbers 200 or above in which the student receives letter grades; and (3) the program must include a total of at least 45 units. Each student’s program is administered by the particular department in which it is lodged and must meet the standard of quality of that department. Transfer into this program is possible from any program within the school by application to the appropriate department.

ENGINEER

The degree of Engineer is awarded at the completion of a comprehensive two-year program of graduate study. It is intended for students who desire more graduate training than can be obtained in an M.S. program. The program of study must satisfy the student’s department and usually includes 90 units beyond the B.S. degree, of which at least 60 must be devoted to advanced or graduate study in the major subject or closely related subjects. 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 found in the individual departmental sections of this bulletin.

DOCTOR OF PHILOSOPHY

Programs leading to the Ph.D. degree are offered in each of the departments of the school. Special Ph.D. programs, which may be interdepartmental in nature (for example, Bioengineering), can be arranged. University regulations for the Ph.D. are given in the “Graduate Degrees” section of this bulletin. Further information is found in departmental listings.

COURSES

(WIM) indicates that the course satisfies the Writing in the Major requirements. (AU) indicates that the course is subject to the University Activity Unit limitations (8 units maximum).

The following Engineering courses deal with subject areas within engineering that are, in their essential nature, broader than the confines of any particular branch of engineering. These courses are taught by professors from several departments of the School of Engineering, under the supervision of those listed below.

Of the courses described in this section, many are of general interest to both engineering and non-engineering students. In addition, certain departmental courses are of general interest and without prerequisites.

Students interested in the interactions between technology and society should also consult the “Science, Technology, and Society” section of this bulletin.

PRIMARILY FOR UNDERGRADUATES

ENGR 1N. The Nature of Engineering—Stanford Introductory Seminar. Preference to freshmen. Hands-on exploration of engineering as a process, activity, profession, and academic discipline. The nature and context of engineering problems. Engineering design and design communication. Measurement, data analysis, uncertainty, and risk. Engineering analysis and the interaction between engineering, science, mathematics, business, and government. Product development, testing, and manufacturing. Engineering education. Design exercises, field trips, problem sets, written reports. Prerequisites: high school physics and calculus. GER:2b

3 units, Aut (Freyberg)

ENGR 2. Introduction to the Disciplines of Engineering—Introduction to the departmental programs in the School of Engineering to show students what opportunities exist for undergraduates in each of those programs. Presentations and tours of laboratories and other department facilities.

1 unit, Spr (Staff)

ENGR 10. Introduction to Engineering Analysis—Integrated approach to the fundamental scientific principles that are the cornerstones of engineering analysis: conservation of mass, atomic species, charge, momentum, angular momentum, energy, production of entropy ex-

pressed in the form of balance equations on carefully defined systems, and incorporating simple physical models. Emphasis is on setting up analysis problems arising in engineering. Topics: simple analytical solutions, numerical solutions of linear algebraic, and laboratory experiences. Provides the foundation and tools for subsequent engineering courses. GER:2b

4 units, Spr (Cappelli)

ENGR 14. Applied Mechanics: Statics—Introduction to the mechanics of particles, rigid bodies, trusses, frames, and machines in static equilibrium, with emphasis on the use of free-body diagrams and the principle of virtual work. Frictional effects and internal forces in structural members. Prerequisite: PHYSICS 41 or consent of instructor. GER:2b

3 units, Aut (Sheppard), Spr (Kiremidjian)

ENGR 15. Dynamics—The application of Newton's Laws to solve static and dynamic problems, particle and rigid body dynamics, freebody diagrams, and writing equations of motion. 2-D and 3-D cases including gyroscopes, spacecraft, and rotating machinery. Solution of equations of motion and dynamic response of simple mechanical systems. Problem sessions. Prerequisites: MATH 23 or 43, PHYSICS 41. GER:2b

3 units, Aut (Niemeyer), Spr (Waldron)

ENGR 20. Introduction to Chemical Engineering—Overview of chemical engineering through discussion and engineering analysis of physical and chemical processes. Topics: overall staged separations, material and energy balances, concepts of rate processes, energy and mass transport, and kinetics of chemical reactions. Applications of these concepts to areas of current technological importance: biotechnology, production of chemicals, materials processing, and purification. Prerequisite: CHEM 31. GER:2b

3 units, Spr (Robertson)

ENGR 25. Biotechnology—The interplay between molecular and cellular biology and engineering principles in the design, development, manufacture, and formulation of new drugs and agrochemicals. Emphasis is on understanding the scope of engineering in modern biotechnology. Topics include biological fundamentals, genomics and bioinformatics, protein engineering, fermentation and downstream recovery of biomolecules, antibody technologies, plant biotechnology, vaccines, transgenic animals, and stem cell technologies. The role of intellectual property and venture capital in biotechnology. Recommended: prior exposure to chemistry and biology. GER:2b

3 units, Aut (Kao)

ENGR 30. Engineering Thermodynamics—Introduction to the concepts of energy and entropy from elementary considerations of the microscopic nature of matter. Use of basic thermodynamic concepts in the solution of engineering problems. Methods and problems in the socially responsible economic generation and utilization of energy in central power stations, solar systems, gas turbine engines, refrigeration devices, and automobile engines. Prerequisites: MATH 19, 20, 21, or 41, 42, and PHYSICS 41 or equivalent. GER:2b

3 units, Aut (Edwards), Win (Pitsch)

ENGR 40. Introductory Electronics—Overview of electronic engineering. Electrical quantities and their measurement including operation of the oscilloscope. The basic function of electronic components including ideal diodes and transistors. Digital logic circuits and their functions including the elementary microprocessor. Analog circuits including the operational amplifier and tuned circuits. Lab assignments. Enrollment limited to 200. Prerequisite: PHYSICS 23. Corequisite: PHYSICS 45. GER:2b

5 units, Aut, Spr (Khuri-Yakub)

ENGR 50. Introductory Science of Materials—Survey of materials, fabrication, and primary applications. Atomic structure and engineering, microelectronics, and memory devices. Mechanical and electronic behavior, semiconductors, alloys, ceramics, composites, and plastics. May

be taken on video at some of Stanford's Overseas Centers; see "Overseas Studies." GER:2b

4 units, Win (Melosh), Spr (Sinclair)

ENGR 60. Engineering Economy—May be taken by freshmen, but recommended for sophomore or higher students. Fundamentals of economic analysis. Interest rates, present value, and internal rate of return. Applications to personal and corporate financial decisions. Mortgage evaluation, insurance decision, hedging/risk reduction, project selection, capital budgeting, and investment valuation. Decisions under uncertainty and utility theory. Prerequisite: MATH 41 or equivalent. Recommended: previous knowledge of elementary probability.

3 units, Aut (Chiu), Win, Sum (Staff)

ENGR 62. Introduction to Optimization—Formulation and analysis of linear optimization problems. Solution using Excel solver. Duality theory. Examples from finance, logistics, economics, pattern recognition, games, and stochastic control. Prerequisite: MATH 51. Recommended corequisite: MS&E 120 or EE 178. GER:2b

3-4 units, Aut, Spr (Van Roy)

ENGR 63Q. Engineering Applications in Medicine—Stanford Introductory Seminar.

3 units (Staff) not given 2003-04

ENGR 70A. Programming Methodology—(Enroll in CS 106A.)

3-5 units, Aut, (Plummer), Win, Spr (Parlante)

ENGR 70X. Programming Methodology and Abstractions (Accelerated)—(Enroll in CS 106X.)

3-5 units, Aut, Win (Sahami)

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

5 units, Aut, Win (Lougee, Staff)

ENGR 102E. Technical/Professional Writing for Electrical Engineers—Required of Electrical Engineering majors. The process of writing technical/professional documents. Lectures, writing assignments, individual conferences. Prerequisite: freshman English. (Corequisite for WIM: EE 108A)

1 unit, Aut, Win (Lougee, Staff)

ENGR 102M. Technical/Professional Writing for Mechanical Engineers—Required of Mechanical Engineering majors. The process of writing technical/professional documents. Lecture, writing assignments, individual conferences. (Corequisite for WIM: ME 203, or consent of instructor)

1 unit, Aut, Win, Spr (Lougee)

ENGR 102S. Writing: Special Projects—(Same as 202S.) Structured writing instruction for students working on non-course related materials (theses, dissertations, journal articles). Weekly individual conferences.

1-5 units, Aut, Win, Spr (Lougee, Staff)

ENGR 102W. Technical and Professional Writing—(Same as 202W.) The process of writing technical and professional documents. Analyzing audiences; defining purpose; generating and selecting appropriate report materials; structuring and designing clear and convincing reports; drafting effective reports; and editing reports that are clear, concise, emphatic, and mechanically and grammatically clean. Weekly writing assignments and individual conferences.

3 units, Aut, Win, Spr (Lougee)

ENGR 103. Public Speaking—Priority to Engineering students. Introduction to speaking activities, from impromptu talks to carefully re-

hearsed formal professional presentations. How to organize and write speeches, analyze audiences, create and use visual aids, combat nervousness, and deliver informative and persuasive speeches effectively. Weekly class practice, rehearsals in one-on-one tutorials, videotaped feedback. Limited enrollment.

3 units, Aut, Win, Spr (Lougee)

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

3 units, Win (Rock)

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

3 units, Aut (Horne, Juanes)

ENGR 130. Science, Technology, and Contemporary Society—(Same as STS 101/201.) Key social, cultural, and values issues raised by contemporary scientific and technological developments; distinctive features of science and engineering as sociotechnical activities; major influences of scientific and technological developments on 20th-century society, including transformations and problems of work, leisure, human values, the fine arts, and international relations; ethical conflicts in scientific and engineering practice; and the social shaping and management of contemporary science and technology. GER:3b

4-5 units, Aut (McGinn)

ENGR 131. Ethical Issues in Engineering—(Same as STS 115.) Moral rights and responsibilities of engineers in relation to society, employers, colleagues, and clients; cost-benefit-risk analysis, safety, and informed consent; the ethics of whistle blowing; ethical conflicts of engineers as expert witnesses, consultants, and managers; ethical issues in engineering design, manufacturing, and operations; ethical issues arising from engineering work in foreign countries; and ethical implications of the social and environmental contexts of contemporary engineering. Case studies, guest practitioners, and field research. Limited enrollment. GER:3a

4 units (Staff) not given 2003-04

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

3-4 units, Spr (Byers)

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

1 unit, Aut (Byers)

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

3 units, Aut (Byers)

ENGR 145. Introduction to High Technology Entrepreneurship—(Same as STS 173.) For juniors, seniors, and coterminial students of all

majors who want to form or grow a technology company some day, and those with a general interest in the field. Overview of the entrepreneurial process, enterprise, and individual. Weekly assignments, case studies, lectures, workshops, and projects.

3 units, Win (Byers, Komisar)

ENGR 150Q. Social Entrepreneurship Startup—Stanford Introductory Seminar. Preference to sophomores. For non-engineering majors. Students learn the art of innovation and social entrepreneurship through a real project for the social sector. Domain experts and entrepreneurs guide research into the problem and its solution. Students produce a briefing book of their findings and a business plan to be further developed in ENGR 250. GER:2b

5 units, Win (Behrman, Paulson)

ENGR 154. Introduction to Engineering Mathematics—Computation and visualization using MATLAB. Differential vector calculus: analytic geometry in space, functions of several variables, partial derivatives, gradient, unconstrained maxima and minima, Lagrange multipliers. Integral vector calculus: Green's, divergence, and Stokes' theorems, multiple integrals in cartesian, cylindrical, and spherical coordinates, line integrals, scalar potential, surface integrals. Introduction to linear algebra, matrix operations, systems of algebraic equations, Gaussian elimination, determinants. Examples and applications drawn from a variety of engineering fields. Prerequisites: MATH 41 and 42, or 10 units AP credit.

5 units, Aut (Khayms), Spr (Darve)

ENGR 155A. Mathematical and Computational Methods for Engineers—Analytical and numerical methods for solving ordinary differential equations arising in engineering applications. Solution of initial and boundary value problems, series solutions, Laplace transforms, and non-linear equations. Numerical methods for solving ordinary differential equations, accuracy of numerical methods, linear stability theory, finite differences. Introduction to MATLAB programming as a basic tool kit for computations. Problems from various engineering fields. Prerequisite: 154 or MATH 51.

5 units, Win (Staff), Spr (Darve)

ENGR 155B. Mathematical and Computational Methods for Engineers—Introduction to linear algebra: matrix operations, systems of algebraic equations, Gaussian elimination, undetermined and overdetermined systems, coupled systems of ordinary differential equations, eigensystem analysis, normal modes. Fourier series with applications, partial differential equations arising in science and engineering, analytical solutions of partial differential equations. Numerical methods for solution of partial differential equations: iterative techniques, stability and convergence, time advancement implicit methods, von Neumann stability analysis. Numerous examples and applications drawn from a variety of engineering fields. Prerequisite: 155A.

5 units, Spr (Khayms)

ENGR 155C. Mathematical and Computational Methods for Engineers—Introduction to probability: random variables, independence, and conditional probability. Discrete and continuous distributions, distributions of several random variables. Topics in mathematical statistics: random sampling, point estimation, confidence intervals, hypothesis testing, non-parametric tests, regression and correlation analysis. Applications in engineering, industrial manufacturing, medicine, biology, and other fields. Topics in constrained and unconstrained optimization, linear programming, numerical methods, and calculus of variations. Prerequisite: 154 or MATH 51.

4 units, Win (Khayms)

ENGR 159Q. Japanese Companies and Japanese Society—Stanford Introductory Seminar. (Same as MATSCI 159Q.) Preference to sophomores. The structure of a Japanese company from the point of view of Japanese society. Visiting researchers from Japanese companies give presentations on their research enterprise, with question and answer

periods. Exploration of the Japanese research ethic. The home campus equivalent of a Kyoto SCTI course.

3 units, Spr (Sinclair)

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

1-15 units, Aut, Win, Spr, Sum (Staff)

PRIMARILY FOR GRADUATE STUDENTS

ENGR 200. Research Universities: Stanford, A Case Study—Goal is to provide insight into how modern research universities work. Topics include the history of Stanford and Silicon Valley; university governance; budgets, finance, and indirect costs; appointments and promotions; how to get research funding; research policies; ethical issues in the publication process; current trends in multidisciplinary scholarship; and Stanford and society. The nominal target audience is prospective and current new faculty, but open to all interested members of the University community.

1 unit, Spr (Kruger, Jones)

ENGR 202S. Writing: Special Projects—For graduate students; see 102S.

1-5 units, Aut, Win, Spr (Lougee, Staff)

ENGR 202W. Technical and Professional Writing—For graduate students; see 102W.

3 units, Aut, Win, Spr (Lougee)

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

3 units, Aut (Tomlin)

ENGR 206. Control System Design and Simulation—Sequel to 105. Analog op-amp circuits are used for simulation and control law implementation. Design of differential actuators and sensors. Model construction techniques. Teams design, build, and test a miniature control system. Emphasis is on qualitative aspects of synthesis, generation of candidate design, and engineering tradeoffs in system selection. Lab. Prerequisite: 105.

4 units, Spr (Niemeyer)

ENGR 207A. Modern Control Design I—Design and analysis of controllers for discrete-time systems. Frequency domain techniques using z-transforms, and time-domain techniques using state-space linear dynamical systems. Introduction to ideas of linear estimation, linear state-feedback control, and optimal control. Simple laboratory experiments on mechanical systems. Prerequisites: 205 or EE 263, and familiarity with basic linear algebra.

3 units, Win (Lall)

ENGR 207B. Modern Control Design II—Design of optimal controllers and optimal estimators for linear dynamical systems. Deterministic linear estimation via least-squares methods, and stochastic minimum variance estimators. The effects of noise on linear systems using frequency-domain and state-space methods. Recursive filtering and smoothing, and the Kalman filter. Prerequisites: 207A and familiarity with basic probability.

3 units, Spr (Lall)

ENGR 209A. Analysis and Control of Nonlinear Systems—First of series. Introduction to nonlinear phenomena: multiple equilibria, limit cycles, bifurcations, complex dynamical behavior. Planar dynamical systems, analysis using phase plane techniques. Describing functions. Lyapunov stability theory. SISO feedback linearization, sliding mode control. Design examples. Prerequisites: 205, MATH 113, EE 263.

3 units, Win (Tomlin)

ENGR 209B. Advanced Nonlinear Control—Second of series. Introduction to differential geometry. Input/output analysis and stability: small gain theorems, passivity theorems, Lure problem. Popov and circle criteria. Geometric nonlinear control. MIMO feedback linearization; backstepping. Design examples. Prerequisite: 209A.

3 units, Spr (Tomlin)

ENGR 210A. Robust Control Analysis and Synthesis—Analysis and design of feedback controllers for systems subject to significant modeling uncertainty and unknown disturbances. Formulation and solution of control design problems using convex optimization. Parameterization of all stabilizing controllers, and computation of stability and performance margins. Prerequisites: 207B or EE 363, or equivalent.

3 units (Staff) not given 2003-04

ENGR 210B. Advanced Topics in Computation for Control—Recent developments in computational methods. Focus is on the use of convex programming to find both exact and approximate solutions to optimization problems: formulation of physical and logical problems as optimization problems involving polynomial equations and inequalities, use of duality and algebraic methods to find feasible points and certificates of infeasibility, and solution of polynomial optimization problems using semidefinite programming. Applications include feedback control methods for multi-vehicle systems and communications networks. Prerequisites: EE 364 or equivalent course on convex optimization; and 207B or EE 363 or equivalent course on control.

3 units, Aut (Lall)

ENGR 220A,B,C. Partial Differential Equations of Applied Mathematics—(Enroll in MATH 220A,B,C.)

3 units, Aut (Liu), Win (Levy), Spr (Yau)

ENGR 235A,B. Space Systems Engineering—40-50 students, mostly from engineering and science, but also from business and political science, form a team to prepare a preliminary design study of a space system. Recently, international engineers have joined the team to define an initiative to put humans on Mars by 2010. Continued studies with Japan, Russia, and Europe define space vehicles for the missions. About 20 invited speakers from government and industry give the necessary background information. At the end of the second quarter, the class gives an oral briefing to government and industry representatives and publishes a final report on the system. Prerequisite: senior or graduate standing in Engineering or Physics, or consent of instructor.

3 units, A: Win, B: Spr (Lusignan)

ENGR 250. Social Entrepreneurship Startup—(Same as OIT 377.) Students learn the art of innovation and social entrepreneurship through a real project for the social sector. Building upon the work of ENGR 150Q, students develop, test, and iteratively improve a technology-based social innovation and a business plan to deploy it. Feedback from domain experts, product designers, manufacturers, successful entrepreneurs, and philanthropic community. Goal is to fund and deploy project.

4-6 units, Spr (Behrman, Kelley, Patell)

ENGR 251. Work Seminar—Students participate in the Creating Research Examples Across the Teaching Enterprise (CREATE) writing program. Goal is for students to produce, through a peer reviewed process, 1,000 word statements describing their research in ways that are understandable and compelling to undergraduates and other novices in the field. Unit credit when the final approved statements appear on the CREATE web site.

1 unit, Aut, Win, Spr (Reis)

ENGR 290. Graduate Environment of Support—Discussion by guest faculty, advanced graduate students, specialists from industry and government, and the dean's office. Topics and information are related to adapting graduate study to the environment in terms of psychosocial, financial, and career issues. How these relate to diversity, affirmative action and minority services, resources, policies, and procedures. Readings and observation participation sessions. (AU)

1 unit, Aut (Osgood, Lozano)

ENGR 297A,B,C. Ethics of Development in a Global Environment (EDGE)—Wednesday evening seminars on world affairs, mostly on issues affecting poor nations. Autumn Quarter treats war and peace: the background of current wars and peace negotiations, the UN peace keeping efforts, war and religion, arms trade. Winter Quarter treats international resources and commerce: the debt crisis, environmental protection, resource depletion, Japan in the world economy, aid and monetary institutions. Spring Quarter treats poverty and prejudice: development models, comparative national health, AIDS, control of wealth, India, China, Africa, S. America today. Expert speakers from Stanford and other institutions who deal directly with world policy makers through research and advisory activities. One unit credit for attendance of the speaker series; 3 units additional credit for workshops treating issues in more depth. Sequential registration not required.

1-4 units, Aut, Win, Spr (Lusignan)

ENGR 298. Seminar in Fluid Mechanics—Interdepartmental seminar on problems in all branches of fluid mechanics, with talks by visitors, faculty, and students. Graduate students may register for 1 unit, without letter grade; a letter grade is given for talks. (AU)

1 unit, Aut (Durbin), Win (Cantwell), Spr (Koseff)

ENGR 299. Special Studies in Engineering—Special studies, lab work, or reading under the direction of a faculty member. Students enroll in the section number corresponding to the particular faculty member. Prerequisite: consent of the instructor.

1-15 units, Aut, Win, Spr, Sum (Staff)

ENGR 310A. Tools for Team-Based Design—(Same as ME 310A.) For graduate students; open to limited SITN/global enrollment. Project-based, exposing students to the tools and methodologies for forming and managing an effective engineering design team in a business environment, including product development teams that may be spread around the world. Topics: personality profiles for creating teams with balanced diversity; computational tools for project coordination and management; real time electronic documentation as a critical design process variable; and methods for refining project requirements to ensure that the team addresses the right problem with the right solution. Computer-aided tools for supporting geographically distributed teams. Final project analyzes industry-sponsored design projects for consideration in 310B,C. Investigation includes benchmarking and meetings with industrial clients. Deliverable is a detailed document with project specifications and optimal design team for subsequent quarters. Limited enrollment.

3-5 units, Aut (Cutkosky, Leifer)

ENGR 310B,C. Design Project Experience with Corporate Partners—(Same as ME 310B,C.) Two quarter project for graduate students with design experience who want involvement in an entrepreneurial design team with real world industrial partners. Products developed are part of the student's portfolio. Each team functions as a small startup company with a technical advisory board of the instructional staff and a coach. Computer-aided tools for project management, communication, and documentation; budget provided for direct expenses including technical assistants and conducting tests. Corporate liaisons via site visits, video conferencing, email, fax, and phone. Hardware demonstrations, peer reviews, scheduled documentation releases, and a team environment provide the mechanisms and culture for design information sharing. Enrollment by consent of instructor; depends on a pre-enrollment survey in December and recommendations by project definition teams in 310A. For some projects, 217 and 218 may be prerequisites or corequisites; see <http://me310.stanford.edu> for admission guidelines.

3-5 units, Win, Spr (Cutkosky, Leifer)

ENGR 311A. Engineering: Women's Perspective—Master's and Ph.D. seminar series driven by student interests. Possible topics: time management, career choices, health and family, diversity, professional development, and personal values. Graduate students share experiences and examine scientific research in these areas. Guest speakers from

academia and industry, student presentations with an emphasis on group discussion. (AU)

1 unit, Win (Sheppard)

ENGR311B. Engineering: Women's Perspective—Continuation of 311A.

1 unit, Spr (Roth)

ENGR 611. Understanding Manufacturing Processes

4 units (Staff) not given 2003-04

ENGR 612E. Manufacturing Organization

4 units (Staff) not given 2003-04

ENGR 614E. Manufacturing Performance Measurement—(Same as GSBGEN T614.) Managerial accounting is devoted to modeling manufacturing processes and representing physical events in economic terms: fundamental issues in measurement theory, cost-volume-profit analysis, activity-based costing, variance analysis, and the costs and benefits of flexibility. Finance functions: capital investment in technology, interactions with the financial markets, capital structure, and taxation. Quality, where modeling of economic effects is a recent phenomenon: statistical process control, cost of quality measures, ISO 9000, the Baldrige Award process, and environmental protection.

4 units (Patell)

ENGR 616E. Proseminar in Manufacturing Education—(Same as OIT 616.) Manufacturing topics not covered in traditional courses needed to help students prepare for academic careers in manufacturing. Topics chosen by students who develop many presentations and lead many discussions. Guest speakers from government, industry, and academia. Primarily for the future professors of manufacturing; others with consent of instructor.

1 unit (Staff)

OVERSEAS STUDIES

These course are approved for the School of Engineering and offered on video overseas at the location indicated. Students should discuss with their major department adviser which courses would best meet individual needs. Descriptions are in the "Overseas Studies" section of this bulletin.

BERLIN

ENGR 40B. Introductory Electronics

5 units, Aut, Win, Spr (Khuri-Yakub)

ENGR 50B. Introductory Science of Materials

4 units, Aut, Win, Spr (Bravman)

FLORENCE

ENGR 50F. Introductory Science of Materials

4 units, Aut, Win, Spr (Bravman)

KYOTO

ENGR 40K. Introductory Electronics

5 units, Spr (Khuri-Yakub)

ENGR 50K. Introductory Science of Materials

4 units, Spr (Bravman)

PARIS

ENGR 40P. Introductory Electronics

5 units, Aut, Spr (Khuri-Yakub)

ENGR 50P. Introductory Science of Materials

4 units, Aut, Win, Spr (Bravman)

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