School of Engineering

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Professors (Research): Paul A. Durbin, Butrus T. Khuri-Yakub
Professors (Teaching): Thomas H. Byers, Robert E. McGinn, Eric S. Roberts
Associate Professor (Teaching): Russell Shackelford
Senior Lecturer: David Lougee
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Consulting Professor: Richard Reis

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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 requirements 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 an Individually Designed Major leading to the B.S. 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 four pre-approved majors: Aeronautics and Astronautics, 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 (21 units):	
MATH 53 or 130, or ME 100. Differential Equations	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 15. Dynamics	5
ENGR 30. Engineering Thermodynamics	3
ENGR 70A. or 70X. Programming (recommended)	5
Two Fundamental courses	(See Basic Requirement 3)
Engineering Depth (39 units):	
AA 100. Introduction to Aeronautics and Astronautics	3
AA 190. Directed Research in Aeronautics and Astronautics (WIM)	3
CEE 180. Structural Analysis	
or ME 111. Stress, Strain, and Strength	3
ENGR 104. Dynamic Behavior	
or ME 161. Dynamic Systems	
or PHYSICS 110. Intermediate Mechanics	3
ME 33. Introduction to Fluids Engineering	4
ME 131A. Heat Transfer	5
ME 131B. Fluid Mechanics	3
Depth Area I*	6
Depth Area II*	6
Engineering Electives†	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.

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

† 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.

BIOMEDICAL COMPUTATION (BMC)

Mathematics (21 units minimum)	(See Basic Requirement 1)
MATH 41. Calculus	5
MATH 42. Calculus	5
STATS 116. Probability	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 & Reactivity	4
BIOSCI 41. Evolution, Genetics, Biochem	5
BIOSCI 42. Cell Biology, Dev. Biology, & 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 unit:	(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)[1]	6
or ME 191 Research Project[1]	
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[2]	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)[3,4]	6
Informatics Breadth (two courses)[4,5]	6
General Breadth (one course)[4,6]	6
Informatics Concentration:	
Mathematics:	
STATS 141. Biostatistics	4
Engineering Fundamentals:	
Elective[2]	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)[7]	9
Cellular Breadth (two courses)[8]	6
Organs Breadth (two courses)[9]	6
Organs/Organisms Concentration:	
Mathematics: one of the following courses:	
MATH 51. Advanced Calculus	5
STATS 141. Biostatistics	5
Engineering Fundamentals:	
Elective[2]	3
Biology (three courses)	
BIOSCI 112. Human physiology	4
BIOC 200. Biochemistry	5
SBIO 211. Structure of Cells & Tissues	7
Simulation Breadth (two courses)[3,4]	6
Informatics Breadth (two course)[4,5]	6
General Breadth (one course)[4,10]	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)[11]	6
Two courses from ENGR 14,15, 30, and ME 80	6
Simulation Breadth (two courses)[12]	6
Cellular Breadth (one course)[8]	6
Organs Breadth (one courses)[10]	3
Total	90-107

1 CS 201 also fulfills the “Writing in the Major” requirement.

2 One course required, 3 to 5 units. See Fundamentals list in School of Engineering Handbook.

3 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.

4 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.

5 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.

6 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

7 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.

8 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.

9 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

10 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, DevBio 210.

11 Different subsets of these courses are required for different continuation courses in the track.

12 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*	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†	
Writing in the Major (one course):	
CS 191W, 194, and 201 fulfill this requirement	
Depth (53 units):	
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**	6-9
Senior Project (CS 191, 191W, or194)††	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, 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, 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)*	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; Mgmt. Sci. & ENGR 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†	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 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 units 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 2002-03 *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 2002-03 *Handbook for Undergraduate Engineering Programs.*

CHEMICAL ENGINEERING (CHE)

Course No. and Subject	*Units*
Mathematics:	
MATH 41, 42	
ENGR 154 Intro to Engineering Mathematics	5
or MATH 51.Calculus	5
or MATH 51 and MATH 52 Calculus	10
ENGR 155A. Mathematical & Computational Methods for Engineers	5
or MATH 52 Calculus	
and MATH 53 Ordinary Differential Equations	10
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
CHEM 131. Organic Polyfunctional Compounds	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 130. Theory and Practice of Identification	4
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	115-124

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*	(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.	3
ENGR 60.	3
Elective	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**	
or Structures and Construction†	32
Other School of Engineering Electives	6-8
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.

† 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, 122A/B, 140, 143, 147, 148, 154, 155, 160, 161, 162, 171, 176A, 176B, 195, 196, 199, 203. See the *Handbook for Undergraduate Engineering Programs* for additional details and the most up-to-date list.

** Environmental and Water Studies: ENGR 30; CEE 101D, 160, 161A, 161B, 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. See the *Handbook for Undergraduate Engineering Programs* for additional details and the most up-to-date list.

COMPUTER SCIENCE (CS)

Mathematics (25 units minimum):	
CS 103X. Discrete Structures (Accelerated)	
or CS 103A and 103B	4-6
MATH 41, 42. Calculus*	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 †	3
MATH 109. Applied Modern Algebra	3
Science (11 units):	
PHYSICS 53. Mechanics	4
PHYSICS 55. Electricity and Magnetism	4
Science Elective**	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 ††	
Writing in the Major (one course):	
CS 191W, 194, and 201 fulfill this requirement	
Computer Science Depth (46 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 182. Computer Organization	4
Two systems electives***	7-8
Applications (two courses):	
CS 121 or 221. Introduction to Artificial Intelligence	3
One applications elective †††	3-4
Project (one course):	
CS 191, 191W, or 194 ****	3
Restricted Electives (two or three courses) ††††	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, 274; and EE 282.

ELECTRICAL ENGINEERING (EE)

Mathematics:	
MATH 41, 42, 51, 52, 53	25
Science:	
PHYSICS (51, 53, 55) or (61, 63, 65)	12
STATS 116, MATH 151, ENGR 156, or EE 178*	4-5
Math or Science Electives:	3-4
Total Math and Science Units	45
Technology in Society (one course):	
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:	
Circuits and Systems: EE 101, 102, 103	9
Electronics: EE 111, 112, 113	11
Laboratory: EE 121 or 108 (WIM), 122	7
Technical Writing: ENGR 102E (WIM corequisite for EE 121)	1
Fields and Waves: EE 141	4
Specialty courses†	9-12
One course in Design**	
Electrical Engineering electives	9-14
Total Engineering 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.

* The Statistics course can count either as a Math and Science elective or as an Electrical Engineering elective, but not both.

† 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), 182, (183, 109, or 281), (271 or 275)
Computer Software: EE 184 (CS 107), 189A (CS 108), 189B (CS 194), (284 or CS 244A)
Controls: ENGR 105, EE 205 (ENGR 205), EE 206 (ENGR 206), EE 209 (ENGR 209)
Electronics: EE 133, 212, 214, 216
Fields and Waves: EE 142, 144, 241, 242, 247
Signal Processing and Communication: EE 104, 133, 168, 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, 183, 281; ENGR 206.

ENVIRONMENTAL ENGINEERING (in CEE)

Mathematics and Science:	
45 unit minimum*	(See Basic Requirement 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 30.	3
ENGR 60.	3
Elective	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. Open Channel Flow	3
CEE 161B. Open Channel Flow Lab	1
CEE 166A. Watersheds and Wetlands	3
CEE 166B. Water Resources	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††	8
Other School of Engineering Electives	2-5
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. See *Handbook for Undergraduate Engineering Programs* for additional details and the most up-to-date list.

MANAGEMENT SCIENCE AND ENGINEERING (MS&E)

Mathematics (28 units minimum*):	(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*):	(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†):**	(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)††	6-10
Engineering Depth (CORE):	
CS 106A. Programming Methodology***	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**	4
Engineering Depth (Concentration: choose one of the following concentrations):	23-30
Industrial Engineering/Operations Management Concentration†††	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****	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
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**	5
Four of the following nine courses:	
MS&E 107. Interactive Management Science	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 212. Network Integer Programming	3
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 (including at least four of ENGR 131, 145; MS&E 130, 164 (WIM), 181, 182, 284):	
ENGR 131. Ethical Issues in Engineering**	4
ENGR 145. Introduction to High Technology Entrepreneurship	3
MS&E 130. Information Systems	4
MS&E 164. Manufacturing Systems Design (WIM)	5
MS&E 181. Issues in Technology and Work in Post-Industrial Economics**	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**	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 two courses:

MS&E 197. Ethics and Public Policy (WIM)**	5
POLISCI 182F. Introduction to American Law	5

One of the following three courses:

EDUC 236X. Education Technology Policy	3
MS&E 193. Role of Technology in National Security (WIM)**	3
MS&E 195. International Security in a Changing World	5

One of the following five courses:

MS&E 237. Progress in Worldwide Telecommunications (Summer only)	3
MS&E 290A. Public Policy Analysis	3
MS&E 290B. Public Policy Analysis	3
MS&E 298. Technology Policy and Management in Newly Developed Countries **	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; CHEMENG 160; CS 147; ENGR 1, 145; MS&E 107, 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*, ME 24 Science and Engineering Options†	9
Total	51

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.

* 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; ME70)
- 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*):	(See Basic Requirement 1)
Science (18 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 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. Integrated 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 two 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 Electronics*
ENGR 50. Introductory Science of Materials*
ENGR 60. Engineering Economics
ENGR 62. Introduction to Optimization
ENGR 70A or 70X. Introduction to Software Engineering

* 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 and their many spinoff technologies. 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*	5
ENGR 15. Dynamics*	5
ENGR 30. Thermodynamics*	3
ME 33. Introductory Fluids	4
ME 131A. Heat Transfer	5
Core Total	12-25

* 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	
Program Total	21-34

Aerospace Systems Synthesis/Design:	
AA 236A,B. Spacecraft Design	6
AA 241A,B. Aircraft Design	6
Dynamics and Controls:	
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
AA 280. Rocket Propulsion	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 having 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-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. 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.
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 (Terman M-17; phone, 3-4969; email street@stanford.edu) is the CEE undergraduate minor adviser, and provides guidance and advice. Students must consult with Professor Robert 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	3
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 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 101. Circuits and Systems I	3
EE 102. Circuits and Systems II	4
EE 103. Introduction to Signal Processing	3
Four graded EE courses of level 100 or higher	
Option II:	
ENGR 40. Introductory Electronics	5
EE 101. Circuits and Systems I	3
EE 111. Electronics I	4
EE 112. Electronics II	4
Four graded EE courses of level 100 or higher	
Option III:	
ENGR 40. Introductory Electronics	5
EE 121. Digital Design Laboratory *or* EE 108. 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.
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 Robert Street (Terman M-17; phone, 3-4969; email 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 Processes and	
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 MSE Core, 16 units):	
MATSCI 190. Organic Materials	4
MATSCI 191. Mathematical & 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 70. Introductory Fluids Engineering	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 131C. Thermodynamics	3
ME 140. Integrated 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	4
ME 80. Stress, Strain, 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 Bldg., 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, immobilized 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, EEH, 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
Hypersonic and Supersonic Flow
Inertial Instruments
Multidisciplinary Design Optimization
Navigation Systems (especially GPS)
Optical Diagnostics in Fluid Dynamics
Optimal Control, Estimation, System Identification
Physical Gas Dynamics
Robust Control of Flexible Spacecraft
Spacecraft Design and Satellite Engineering
Shock Tube Studies of Vortex Interactions
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 Geometry
Computational Physics
Computer Logic
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 units of courses within the School of Engineering with numbers 200 or above in which the student receives letter grades, (3) the program must include a total of at least 45 units. Each student's program is administered by the particular department in which it is lodged and must meet the standard of quality of that department. Transfer into this program is possible from any program within the school by application to the appropriate.

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

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

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

5 units, Aut (Steele), Spr (Staff)

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 (Khosla, 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 (Mungal), Win (Edwards)

ENGR 40. Introductory Electronics—Overview of electronic engineering. Electrical quantities, and their measurement, including the 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 complement lecture. Enrollment limited to 200. Lab. May be taken on video at some of the Stanford's Overseas Centers; see "Overseas Studies." Prerequisite: PHYSICS 23. Corequisite: PHYSICS 45. GER:2b

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

ENGR 50. Introductory Science of Materials—Survey of Materials, fabrication and primary applications. Atomic structure & engineering, microelectronics and memory devices. Mechanical and electronic behavior, alloys, ceramics, composites, plastics, etc. May be taken on video at some of Stanford's Overseas Centers; see "Overseas Studies." GER:2b

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

ENGR 60. Engineering Economy—May be taken by freshmen, but recommended for second year or higher students. Economic analysis for choice among alternatives. Use of compound interest calculations. Selection of appropriate minimum attractive rates of return. Effects of depreciation, sources of funds, and income tax. Analysis of decisions under uncertainty. Prerequisite: MATH 41 or equivalent. Recommended: previous knowledge of elementary probability.

3 units, Aut (Chiu), Win (Primbs), Sum (Bhimjee)

ENGR 62. Introduction to Optimization—Formulation of linear and convex quadratic optimization problems. Solution through use of available computational tools. Examples drawn from logistics, networks, electronics, classification and regression, stochastic control, games, combinatiorial optimization, finance, and economics. Sensitivity and duality. Introduction to optimization algorithms. Prerequisite: MATH 51 or comparable background in linear algebra. Recommended: MS&E 120, EE 178, or comparable background in probabilistic modeling (taken previously or concurrently). GER:2b

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

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

3 units, not given 2002-03

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

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

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

3-5 units, Aut, Spr (Zelenski)

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: EE 108 or 121. (WIM)

1 unit, Aut, Win, Spr (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. Pre- or corequisite: ME 103, or consent of instructor. (WIM)

1 unit, Aut, Win (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 (Lougee)

ENGR 103. Public Speaking—Priority given to Engineering students. Introduction to the full range of speaking activities, from impromptu talks to carefully rehearsed formal professional presentations. How to organize and write speeches for a variety of occasions, analyze audiences, create and use appropriate visual aids, combat nervousness, and deliver informative and persuasive speeches effectively. Students become confident speakers through weekly practice in class, rehearsals in one-on-one tutorials, and videotaped feedback. Enrollment limited.

3 units, Aut, Win, Spr (Lougee, Staff)

ENGR 104. Dynamic Behavior—A prelude to automatic control. Models for real physical systems (mechanical, electrical, electromechanical, thermal, and fluid). Derivation of equations of motion. Linearization and superposition. Delta function and convolution. Natural and forced motions for mechanical, electrical, and other systems. Characteristics and stability of natural motion and natural modes. Introduction to Evans root-locus method. Elements of frequency response. Fourier and Laplace transform techniques. Total response from partial fraction expansion. Observation and report of laboratory dynamics experiments. Prerequisite: PHYSICS 43 or equivalent.

3-4 units (Staff) not given 2002-03

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: 104, EE 102, or ME 161.

3 units, Aut (Enge)

ENGR 120. Fundamentals of Petroleum Engineering—(Same as PETENG 120.) Lectures, problems, field trip. Basic engineering topics in petroleum recovery; origin, discovery, and development of oil and gas. The 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 (Caers, Gerritsen)

ENGR 130. Science, Technology, and Contemporary Society—(Same as STS 101/201.) Graduate students register for 201. Analysis of the interplay of science, technology, and society in the contemporary U.S. Topics: the 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.) Ethical issues in contemporary engineering practice. Topics: the 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. Use of real life case studies, guest practitioners, and field research. Limited enrollment. GER:3a

4 units, not given 2002-03

ENGR 140A. Management of Technology Ventures—First of three-part sequence only for students selected to the Mayfield Fellows Program. Functional 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 building strategies, and the challenges of managing growth and handling adversity in emerging ventures. Other engineering faculty, startup founders, and venture capitalists participate as appropriate. No auditors. Recommended: accounting or finance course (Management Science and Engineering 140, Economics 90, or Engineering 60).

3-4 units, Spr (Byers)

ENGR 140B. Management of Technology Ventures—Open to Mayfield Fellows only; taken during the summer work tour at a technology startup. Students meet to exchange experiences and continue the formal learning process, and keep a journal of activities. Credit given following quarter. No auditors.

1 unit, Aut (Byers)

ENGR 140C. Management of Technology Ventures—Open to Mayfield Fellows only. Allows students, faculty, employers, and venture capitalists to share and compare recent co-op experiences and analytical frameworks. Students develop living case studies and integrative project reports. No auditors.

3 units, Aut (Byers)

ENGR 145. Introduction to High Technology Entrepreneurship—(Same as STS 173.) A high-level overview of the entrepreneurial process, enterprise, and individual. For those who would like to form or grow a technology company, and those with a general interest in the field. Weekly assignments, case studies, lectures, workshops, and projects. For juniors and seniors in engineering, sciences, and humanities. No auditors.

3 units, Win (Byers)

ENGR 154. Introduction to Engineering Mathematics—Introduction to computation and visualization using MATLAB. Differential vector calculus: analytic geometry in space, functions of several variables, partial derivatives, gradient, directional derivatives. Topics in optimization: unconstrained optimization, maxima and minima at the boundaries, method of steepest descent, optimization with equality constraints, Lagrange multipliers. Integral vector calculus: double and triple integrals in cartesian, cylindrical, and spherical coordinates, transformation of variables, line integrals, circulation, Green's theorem, scalar potential, path independence, surface integrals, divergence and Stokes' theorems. Introduction to linear algebra, matrix operations, systems of algebraic equations, Gaussian elimination, undetermined and overdetermined systems, linear independence. Limited enrollment. Prerequisites: MATH 41 and 42, or 10 units of AP credit.

5 units, Aut, Spr (Staff)

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 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. Introduces MATLAB as a basic tool kit for computations. Problems from various engineering fields. Prerequisite: 154, MATH 51.

5 units, Win, Spr (Staff)

ENGR 155B. Mathematical and Computational Methods for Engineers—Fourier series, transforms, and applications, partial differential equations arising in science and engineering, analytical solutions of partial differential equations, numerical linear algebra, least squares, coupled systems of ordinary differential equations, eigensystem analysis, normal modes, numerical methods for solution of partial differential equations, iterative techniques, stability and convergence, time advancement, implicit methods, von Neumann stability analysis. Prerequisite: ENGR 155A.

4 units, Spr (Staff)

ENGR 155C. Mathematical and Computational Methods for Engineers—Introduction to probability, counting, permutations and combinations. Random variables, independence and conditional probability. Discrete in mathematical statistics: estimation, confidence intervals, hypothesis testing, decision theory. Applications in industrial manufacturing. Regression and correlation analysis with applications. Vector calculus, constrained and unconstrained optimization, linear programming, numerical methods. Double and triple integrals, line integrals, and path independence. Surface integrals, Green's theorem, divergence and Stokes' theorems. Prerequisite: E155A.

4 units, Win (Khyams)

ENGR 159Q. Research in Japanese companies—(Same as MATSCI 159Q.) Stanford Introductory Seminar. Preference to sophomores. The home campus equivalent of the Kyoto course. Knowledge from this research, and company visits. The structure of a Japanese company from the point of view of Japanese society. Visiting researchers from Japanese companies, with brief presentations and extensive question and answer periods, explore the Japanese research ethic.

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, any quarter (Staff)

PRIMARILY FOR GRADUATE STUDENTS

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 (Lougee)

ENGR 205. Introduction to Control Design Techniques—Review of root-locus and frequency response techniques for control system and analysis, and synthesis. Introduction to: digital control design and the z-transform; state-space techniques 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 digital controllers using classical and state space techniques. Discretization of continuous systems, z-transforms, and direct digital design. Pole placement and optimal quadratic regulators for single-input/single-output and multiple-input/multiple-output discrete systems. Discrete observers and optimal estimators. Simple lab experiments on mechanical systems. Prerequisites: 205; MATH 103 or ME 200A.
3 units, Win (Lall)

ENGR 207B. Modern Control Design II—Design of optimal controllers and estimators for systems with stochastic disturbances. Basic probability theory, identification techniques, recursive filtering, duality, and properties of optimal regulators. Sensitivity, robustness, and design trade-offs. Extensions to other cost functions. Lab experiments on computers connected to mechanical systems. Prerequisite: 207A. Recommended: EE 278 or STATS 116.
3 units, Spr (Lall)

ENGR 209A. Analysis and Control of Nonlinear Systems—First of series in nonlinear systems. 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 from a variety of areas. Prerequisites: 205, MATH 113, EE 263.
3 units, Win (Tomlin)

ENGR 209B. Advanced Nonlinear Control—Second of series in nonlinear systems. 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 from a variety of areas. Prerequisite: 209A.
3 units, Spr (Tomlin)

ENGR 210A. Robust Control Analysis and Synthesis—Design of optimal compensators for systems with plant modeling errors and unknown disturbances. Performance specifications and limitations, model uncertainty, stability robustness, and the robust performance problem. Topics: generalization of Linear Quadratic Gaussian designs, linear fractional transformations, H-infinity synthesis, structured singular values, and the D-K iteration, fixed-order robust control design. Prerequisites: 207B, EE 263, and experience with Matlab.
3 units, Aut (Lall)

ENGR 211. System Identification—Construction of dynamic models from input-output data. Least squares and maximum likelihood methods. Parameter estimation and identifiability. Frequency domain curve fitting and time domain methods (ERA and Subspace). Error modeling for control. Simple lab experiments. Prerequisites: 207B, EE 263, and experience with Matlab.
3 units (Staff)

ENGR 220A,B,C. Partial Differential Equations of Applied Mathematics—(Enroll in MATH 220A.)
3 units, Aut, Win, Spr (J. Levandosky)

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 a verbal 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.
235A. *3 units, Win (Lusignan)*
235B. *3 units, Spr (Lusignan)*

ENGR 251. Work Seminar—Seminar. Students participate in the Creating Research Examples Across the Teaching Enterprise (CREATE) writing program. The goal is to have students 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 (Roberts, Lozano)

ENGR 297A,B,C. Ethics of Development in a Global Environment (EDGE)—(Same as CASA 133A,B,C.) 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. Speakers from Stanford and other institutions are experts who directly deal with world policy makers through research and advisory activities. One unit credit for attendance of the speaker series; 3 units additional credit for optional workshops treating selected issues in more depth. (Sequential registration not required.)
1-4 units, Aut, Win, Spr (Lusignan, Gupta)

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 (Shaqfeh), Win (Moin), Spr (Durbin)

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, any quarter (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 useful 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 are employed for supporting geographically distributed teams. The final project analyzes a set of industry-sponsored design projects for consideration in 310B,C. The investigation includes benchmarking and meetings with industrial clients. The deliverable is a detailed document with specifications for the project and the optimal design team that should work on the project in subsequent quarters. Limited enrollment.

3-5 units, Aut (Cutkosky)

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

3-5 units, Win, Spr (Cutkosky)

ENGR 311A,B. 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. Guests speakers from academia and industry, student presentations with an emphasis on group discussion. (AU)

1 unit, Win, Spr (Sheppard)

ENGR 611. Understanding Manufacturing Processes

4 units

ENGR 612E. Manufacturing Organization

4 units

ENGR 614E. Manufacturing Performance Measurement—(Same as Business T614.) Managerial accounting as a discipline 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 relatively 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.) This seminar exposes students to manufacturing topics not covered in traditional courses and that are needed to help them prepare for academic careers in manufacturing. Topics are chosen by the students, who develop many of the presentations and lead many of the discussions. The seminar also features guest speakers from government, industry, and academia. Intended primarily for the Future Professors of Manufacturing, but open to others with permission of the instructor. Also listed as General Engineering 616E.

1 unit

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 40F. Introductory Electronics

5 units, Aut (Khuri-Yakub)

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)

OXFORD

ENGR 40X. Introductory Electronics

5 units, Aut, Spr (Khuri-Yakub)

PARIS

ENGR 40P. Introductory Electronics

5 units, Aut, Spr (Khuri-Yakub)

ENGR 50P. Introductory Science of Materials

4 units, Aut, Win, Spr (Bravman)

PUEBLA

ENGR 40M. Introductory Electronics

5 units, Win (Khuri-Yakub)