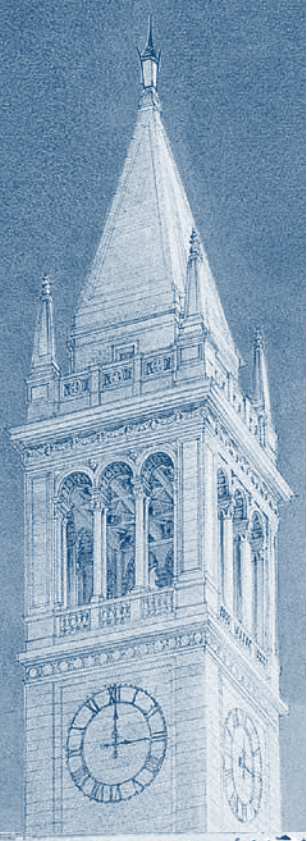
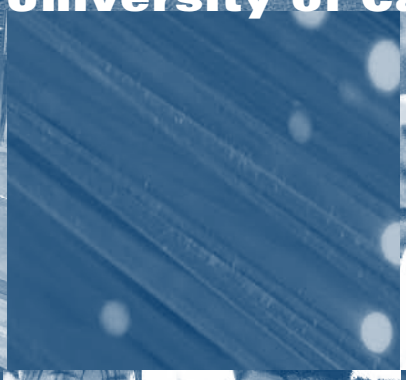
2010-2011 announcement

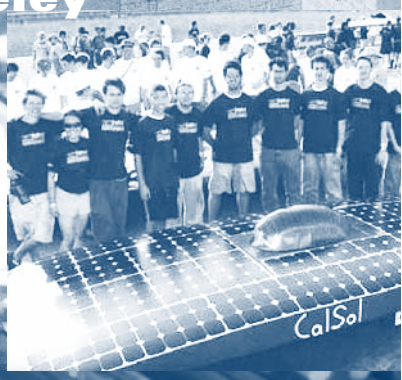
College of Engineering

A Guide to Undergraduate and Graduate Study



University of California, Berkeley





Educating Leaders.
Creating Knowledge.
Serving Society.

Academic Calendar 2010-11

Fall Semester 2010

Tele-BEARS Begins	April 12	Monday
Fee Payment Due	August 15	Sunday
Fall Semester Begins	August 19	Thursday
Welcome Events	August 23-27	Monday-Friday
Instruction Begins	August 26	Thursday
Labor Day Holiday	September 6	Monday
Homecoming	October 8-10	Friday-Sunday
Veterans Day Holiday	November 11	Thursday
Thanksgiving Holiday	November 25-26	Thursday-Friday
Formal Classes End	December 3	Friday
Reading/Review/Recitation Week	December 6-10	Monday-Friday
Instruction Ends	December 10	Friday
Final Examinations	December 13-17	Monday-Friday
Fall Semester Ends	December 17	Friday
Winter Holiday	December 23-24	Thursday-Friday
New Year's Holiday	December 30-31	Thursday-Friday

Spring Semester 2011

Tele-BEARS Begins	October 18, 2010	Monday
Spring Semester Begins	January 11	Tuesday
Fee Payment Due	January 15	Saturday
Martin Luther King Jr. Holiday	January 17	Monday
Instruction Begins	January 18	Tuesday
Presidents' Day Holiday	February 21	Monday
Spring Recess	March 21-25	Monday-Friday
César Chávez Holiday	March 25	Friday
Cal Day	April 16	Saturday
Formal Classes End	April 29	Friday
Reading/Review/Recitation Week	May 2-6	Monday-Friday
Instruction Ends	May 6	Friday
Final Examinations	May 9-13	Monday-Friday
Spring Semester Ends	May 13	Friday

Summer Sessions 2011

Tele-BEARS Begins	February 7	Monday
First Six-Week Session	May 23-July 1	Monday-Friday
Memorial Day Holiday	May 30	Monday
Ten-Week Session	June 6-August 12	Monday-Friday
Eight-Week Session	June 20-August 12	Monday-Friday
Independence Day Holiday	July 4	Monday
Second Six-Week Session	July 5-August 12	Tuesday-Friday
Three-Week Session	July 25-August 12	Monday-Friday

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College of Engineering home page: coe.berkeley.edu.


ENGINEERING

From the Dean

This is truly an amazing time to be an engineer. Science and technology have an impact on nearly every facet of our daily lives — how we communicate, travel, obtain information, protect and preserve our environment, improve our health, build and protect our cities, and solve many of today's most pressing problems. UC Berkeley's College of Engineering prepares students to meet these challenges as leaders, with creativity and innovation.

The engineering programs described within these pages offer a solid foundation in mathematics and science to prepare students for specialization in one of our engineering departments or interdisciplinary programs. In addition, the engineering curricula call for study in the humanities and social sciences, to give students the well-rounded background needed to contribute to our increasingly complex and multifaceted society.

Our engineering student organizations, a vital part of the College, also offer many opportunities to develop the communication and leadership skills that are essential in all aspects of a well-rounded professional career.

This announcement — read in conjunction with the *General Catalog* and the College of Engineering website — explains procedures and outlines courses of study in the College. I urge you to seek out all that the College and University have to offer — courses, special seminars and lectures, alumni events, and the breadth of cultural activities hosted by the Berkeley campus. This will enrich your years at Berkeley and your preparation for a rewarding career in engineering.

S. Shankar Sastry
Dean and Roy W. Carlson Professor,
College of Engineering

◀ ***McLaughlin Hall, the main administration building for the College of Engineering***

About the College of Engineering

UC Berkeley Engineering is a community that is dedicated to creating tomorrow's leaders and supporting today's pioneers. Students and researchers from around the world are drawn to Berkeley by its outstanding reputation, its internationally recognized faculty, and its strong tradition of impact in research and teaching.

Earlier Berkeley engineers brought water to California's great agricultural lands, pioneered the microelectronics that seeded Silicon Valley, and helped build the unbuildable in structures like the Hoover Dam and the Golden Gate Bridge. Today, Berkeley engineers in every field remain at the center of technological innovation worldwide.

Choosing Engineering

Engineers are problem solvers. Drawing on a solid foundation in math and the sciences, engineers develop efficient ways to improve our quality of life. And when technological progress creates adverse side effects, engineers work to remedy them.

Is Engineering for You?
If you see yourself as a designer or builder — whether of structures, machines, electrical circuits, or systems of operation — then engineering may be right for you.

If you would like to work as a manager or administrator of a technical enterprise, an engineering degree could be the best background to meet your goals.

If you imagine yourself as a researcher in a technical field, then an education in engineering or one of the physical sciences may be your right choice. Most engineering research is directed toward a specific objective, applying science to meet a human need. It is most often a team effort, involving people with engineering, science, business, and other backgrounds.

An Engineering Education. As rapidly as technology evolves, engineering evolves a step ahead, incorporating new knowledge and emerging technologies. Engineering today is broadly interdisciplinary; solving today's challenges requires engineers from many disciplines working together with experts in such fields as business, biology, medicine, public policy, and economics.

◀ ***Historic Hearst Memorial Mining Building, ornamented with suspended foam balls installed by artist J. Ignacio Díaz de Rábago and a team of interdisciplinary Berkeley students***

Engineering: The Berkeley Equation

UC Berkeley engineering students are not only taught by leading engineers, they also benefit from top faculty in every field and the resources of one of the world's great intellectual centers.
In the latest survey by the National Research Council, 35 of 36 programs at Berkeley ranked in the top 10, more than any other university, public or private.

Berkeley is not your typical place, and there are no typical Berkeley students. They are musicians, politicians, athletes, scientists, writers — bound together simply by their passion for learning. Students hail from every region in California, each state in the union and over 100 countries, and represent all backgrounds.

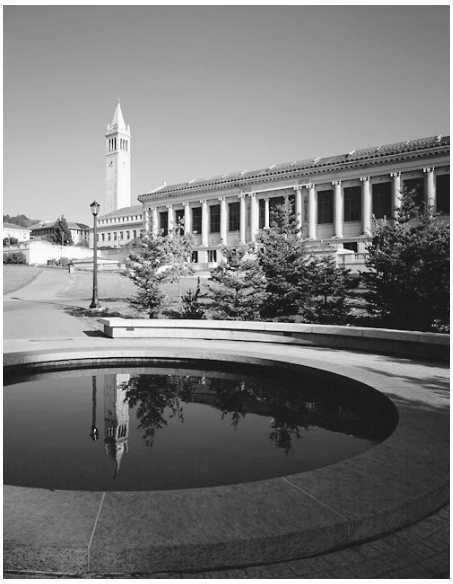
On any given day at Berkeley, one could find themselves in a classroom being taught by a Nobel laureate, at a free concert by a local independent rock band, an information session for the concrete canoe team, a football game with over 75,000 California Golden Bears (Cal) fans, or shopping on world-famous Telegraph Avenue.

When in Berkeley...

Sheltered by rolling hills and the San Francisco Bay, Berkeley is a vibrant and spirited city of surpassing richness. The University, the City of Berkeley, and the San Francisco Bay Area combine to form an extraordinary environment for all types of educational, artistic, and recreational pursuits.

Coffee houses, bookstores, and vendors line the streets near campus, and lecturers, artists, and performers from around the world make sure to visit UC Berkeley.

If you want to head into San Francisco, a city full of cultural and recreational opportunities, Bay Area Rapid Transit (BART) is just a few blocks away in downtown Berkeley. Scenic Napa Valley, just one hour's drive north of Berkeley, produces some of the best wines in the country. Regardless of what you choose to do, you won't find a more temperate climate or a more beautiful setting.



Opportunities and Services

College of Engineering Student Information Online Resources

For more information on programs and resources narrated in this section, please see the following websites:

Engineering Student Services Office
coe.berkeley.edu/students

Academic Advising and Support:
coe.berkeley.edu/advising

Student Involvement:
coe.berkeley.edu/student-involvement

Kresge Engineering Library:
lib.berkeley.edu/ENGI

Undergraduate Research:
coe.berkeley.edu/student-research

Freshman and Sophomore Seminars:
fss.berkeley.edu

Continuing Education:
extension.berkeley.edu

Broadening Participation Initiatives (MEP, GrAD, JMEP, SUPERB):
coe.berkeley.edu/bpi

Alumni Relations:
coe.berkeley.edu/alumni

Supporting the College:
coe.berkeley.edu/support-the-college

Other Student Information Websites

Campus Life and Leadership:
cll.berkeley.edu

Career Center:
career.berkeley.edu

Financial Aid:
financialaid.berkeley.edu

Housing and Dining Services:
housing.berkeley.edu

University Health Services:
uhs.berkeley.edu

College of Engineering

Engineering Student Services (ESS)

230 Bechtel Engineering Center
(510) 642-7594

Engineering Student Services (ESS) provides comprehensive services in all matters pertaining to undergraduate engineering students, including academic enrichment and broadening participation.

Student Activities and Support Services

Advising and Academic Support

Each undergraduate in the College of Engineering is assigned both a student academic adviser and faculty adviser at the time of admission. As appropriate, students will continue with these advisers throughout their undergraduate careers. Student academic advisers guide students in academic requirements and assist with academic questions or concerns. Faculty advisers serve as academic and professional mentors and aid in long-term course planning, locating research opportunities, and finding information regarding their respective fields.

Academic departments also have advisers to help students learn more about programs, facilities, and research, and point students toward appropriate faculty contacts.

A wide selection of tutoring and additional support services are available at the University, College, and departmental levels, including alumni mentorships, peer advising, and other student group programs that provide mentoring and tutoring.

Graduate students should consult their department for information on support and advising services.

Student Involvement

An engineering education at Berkeley does not begin and end in the classroom. Active participation in student organizations enhances and broadens a student's experience and provides opportunities to integrate material learned in the classroom with a chance to develop character and leadership skills. Through professional societies, campus groups, award-winning competitive engineering teams, and publications, students are encouraged to explore engineering and its implications with their peers, faculty, and practicing engineers.

Engineering Libraries

The 22,000-square-foot Kresge Engineering Library provides 250 stations for reading or studying, access to the campus wireless network, and an array of electronic information resources. The library's collection includes approximately 256,000 volumes, over 2,700 engineering journals in electronic and/or print format, thousands of electronic books in engineering, and over 730,000 technical reports.

In addition to the Kresge Engineering Library, the College is served by three specialized libraries: the Water Resources Center Archives, Earthquake Engineering Research Center Library, and Harmer E. Davis Transportation Library.

Student Center

The Stephen D. Bechtel Engineering Center is the intellectual and social hub of the College. The center houses the Kresge Engineering Library, and Engineering Student Services. The Sibley Auditorium of the Bechtel Center accommodates large audiences for visiting speakers, and conference rooms provide places where students can meet with professional engineers and alumni. In addition, the center houses the offices of student organizations and adjoining lounges for informal student activities.

Academic Enrichment Opportunities

Undergraduate Research

Undergraduate research plays an important role in the educational experience and provides practical skills for future employment and graduate school. Engineering students have a wide range of opportunities throughout the College and University to participate in groundbreaking research with faculty and graduate students.

Freshman and Sophomore Seminars

The College of Engineering provides a number of introductory courses of interest to freshmen and sophomores. These courses are generally not in the required programs but are for enrichment, orientation to the College and major, and guidance in the profession. They provide an unparalleled opportunity for faculty members and small groups of lower division students to explore a scholarly topic of mutual interest together.

Continuing Education

UC Berkeley Extension provides a broad range of technical courses for engineers, engineering managers, environmental management personnel, and engineering-oriented personnel in related fields who are interested in updating their knowledge in their own field or in exploring other areas of engineering. The most recent advances and newest technologies are covered in intensive short courses, evening classes, online courses, and lecture series in fields including construction management.

Broadening Participation Initiatives

Charles Tunstall Multicultural Engineering Program (MEP)

The objective of the Charles Tunstall Multicultural Engineering Program is to increase the number of underrepresented students who enroll and graduate with bachelor's degrees in engineering from Berkeley. MEP provides outreach and recruitment activities; an academic enrichment summer program; counseling and advising; academic support (i.e., workshops, individual and group tutoring); and information on financial assistance, research opportunities, and graduate school.

Graduate Academic Diversity (GrAD) Program

The Graduate Academic Diversity Program (GrAD) provides support services for prospective and current students in the College of Engineering. It advises applicants on opportunities in the College, the graduate admissions process, fellowships, and academic support services of the College and the Berkeley campus, and it provides a forum for ideas and programs designed to enhance the educational experience and broaden participation of underrepresented engineering students.

Julia Morgan Engineering Program (JMEP)

The mission of the Julia Morgan Engineering Program (JMEP) is to support all students to achieve their full potential in careers as engineers and leaders and to call greater attention to the contributions of women in engineering. JMEP provides academic support and programming, such as pre-admissions advising, tutoring, and graduate school advising.

Summer Undergraduate Program in Engineering Research at Berkeley (SUPERB)

SUPERB offers outstanding underrepresented students and students who have been educationally or economically disadvantaged the opportunity to gain research experience by participating in eight-week summer research projects with engineering faculty and graduate students.

Alumni and Support for the College of Engineering

Berkeley Engineering Events & Programs

Every student graduating from the College of Engineering or in chemical engineering belongs to the Berkeley Engineering family. The College's events and programs department hosts a number of social and professional development events for students throughout the year to help them connect with each other, meet alumni mentors, and prepare for their careers. Events include:

- Engineering Career Portfolio showcasing alumni speakers with advice on résumé writing, preparing for job interviews, and more
- New student orientation
- Homecoming activities for students, parents, and alumni
- Feed the Bears snack breaks during finals week
- Cal Day tours, lectures, and lab tours for new incoming students
- Commencement
- And much more!

Support for the College

Through gifts to the Berkeley Engineering Annual Fund, alumni, parents, friends, faculty, and students help ensure the College's continued excellence as one of the premier engineering educational and research institutions in the world. The Annual Fund supports a number of initiatives intended to enhance a student's experience while at Berkeley Engineering, such as:

- Undergraduate research opportunities
- Start-up funding to attract and hire talented new professors
- Innovative student leadership projects like the concrete canoe team
- BEAR social and professional development events
- *Forefront*, the college's magazine highlighting research and student accomplishments
- Center for Entrepreneurship and Technology

Admission and Degree Requirements

Undergraduate Admission and Degree Requirements Online Resources:

For more information on the topics in this section, please see the following websites:

UC Berkeley General Catalog:
catalog.berkeley.edu

Office of Undergraduate Admissions:
admissions.berkeley.edu

College of Engineering Prospective Students:
coe.berkeley.edu/prospective-students

Transfer Admission Program Requirements/Course Articulation:
assist.org

Undergraduate Student Advising:
coe.berkeley.edu/advising

Humanities/Social Sciences (H/SS) Requirement:
coe.berkeley.edu/hssreq

Undergraduate Handbook:
coe.berkeley.edu/undergradhandbook

Undergraduate Programs

Students in the College of Engineering at Berkeley may elect one of the curricula listed below. Each is four years in length and leads to the Bachelor of Science degree.*

Bioengineering[3]
Civil Engineering[1]
Electrical Engineering and Computer Sciences
Electrical and Computer Engineering[1]
Computer Science and Engineering[2]
Engineering Science[3]
Computational Engineering Science
Engineering Mathematics and Statistics
Engineering Physics
Environmental Engineering Science
Industrial Engineering and Operations Research[1]
Manufacturing Engineering[3]
Materials Science and Engineering[1]
Mechanical Engineering[1]
Nuclear Engineering[1]

Joint Majors[3]
Bioengineering and Materials Science and Engineering
Electrical Engineering and Computer Sciences and Materials Science and Engineering
Electrical Engineering and Computer Sciences and Nuclear Engineering
Materials Science and Engineering and Mechanical Engineering
Materials Science and Engineering and Nuclear Engineering
Mechanical Engineering and Nuclear Engineering

—

Chemical Engineering and Materials Science and Engineering
Chemical Engineering and Nuclear Engineering

(Chemical Engineering and the Chemical Engineering joint major programs are offered through the College of Chemistry and are described in detail in the *Announcement of the College of Chemistry.*)

Undergraduate Minors

Bioengineering
Computer Science
Electrical Engineering and Computer Science
Environmental Engineering (Civil and Environmental Engineering)
Geoengineering (Civil and Environmental Engineering)
Industrial Engineering and Operations Research
Materials Science and Engineering
Mechanical Engineering
Nuclear Engineering
Structural Engineering (Civil and Environmental Engineering)

*In addition to the majors listed, freshman applicants may apply to the Engineering — Undeclared admission option. This option is designed for students with a strong background and interest in mathematics and physics who have not yet identified a specialization within engineering. After completing the Engineering — Undeclared curriculum, the student must transfer into a degree program for the final two years. For more information, see the Engineering — Undeclared section of this announcement.

[1]These B.S. programs are accredited by the Engineering Accreditation Commission of the ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700.

[2]This B.S. program is accredited by the Computing Accreditation Commission of ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700.

[3]This program is not accredited by the Engineering Accreditation Commission or Computing Accreditation Commission of the ABET, Inc.

Admission

Admission to Undergraduate Programs

The College of Engineering admits students at the freshman and junior-transfer levels.

All applications are administered by the University's Office of Undergraduate Admission. See the *General Catalog* or visit the admissions Website for details on requirements and the application process.

Additional information for prospective College of Engineering applicants may be found on the College's Prospective Students webpage.

Admission to Joint Major Programs

Freshman Admits. Students admitted to the College of Engineering as freshmen may apply to a joint major once they have completed two semesters at UC Berkeley. Historically, students need a GPA of 3.0 or higher to be admitted to a joint major program. (Students in the Engineering Undeclared program are eligible to declare a joint major if they have a GPA of at least 2.0 and are in good academic standing.) Engineering students considering a joint major are advised to meet with their adviser in the Engineering Student Services Office to learn more about the process. See coe.berkeley.edu/joint-majors for more information.

Junior Transfer Applicants. Junior transfer applicants may apply directly to one of the joint major programs. Transfer students interested in a joint major should carefully review the specific graduation requirements for the program before submitting their application. See the College's Prospective Students webpage for more details on transfer admission and requirements.

Chemical Engineering Joint Majors. The joint majors with Chemical Engineering are administered by the College of Chemistry. College of Engineering students and transfer applicants interested in a joint major with Chemical Engineering must apply to the College of Chemistry.

Admission to Minor Programs

Admission to minors programs is administered by the respective department. See the "Academic Departments and Program" section of this announcement or the department website for more information.

Admission from another college at UC Berkeley

Students who have completed two semesters of coursework at UC Berkeley may petition to transfer to the College of Engineering from another college on campus. Admission is competitive. Applications are reviewed twice a year (March and October). Interested students should review the information on change of college available at coe.berkeley.edu/prospective-students.

Admission as a Second Bachelor's Degree candidate

Although this is ordinarily discouraged, some applicants who already hold a bachelor's degree in a nontechnical or non-engineering field may be considered for admission. Applicants interested in a second degree should contact Engineering Student Services for further information.

Readmission

Students who withdrew after the first eight weeks of classes and before the end of the semester are not eligible for readmission until

one year from the beginning of the semester in which the withdrawal was granted.

Continuing students who are eligible to attend the following semester but fail to do so are required to apply for readmission to the University for any future semester that they wish to attend. Students who are granted withdrawal are also required to apply for readmission in order to resume study in a future semester.

Readmission is not guaranteed and is based upon the students' academic record at the time of withdrawal and upon any course work taken during their absence from UC Berkeley. Students whose records are not satisfactory should not expect to be readmitted. Courses taken for the purpose of readmission must be approved by the associate dean before the student takes the courses. An academic plan indicating courses expected to be taken and places of attendance must be submitted to the associate dean.

Students returning to the University after an absence *must meet the requirements of their degree program in effect at the time they are readmitted.* If students have attended other institutions during their absence from the University, they must present an official transcript of record from each college before readmission will be considered.

Students who are applying for readmission after dismissal should discuss readmission with their student academic adviser at the time of their dismissal.

General Degree Requirements

Engineering students must fulfill University of California, Berkeley campus and the College of Engineering requirements to graduate.

University Requirements

Students must complete the general University requirements of Entry-Level Writing (formerly Subject A) and American History and Institutions discussed in the *General Catalog.*

Berkeley Campus Requirements

The Berkeley campus American Cultures Breadth requirement is satisfied by passing an approved course that is integrative and comparative and addresses theoretical and analytical issues relevant to understanding race, culture and ethnicity in American history and society. See the *General Catalog* for more information.

College of Engineering Requirements

Students in the College of Engineering must complete 120 semester units with the following provisions:

(1) Completion of the requirements of one program of study

(2) A minimum overall grade point average of 2.00 (C average) and a minimum of 2.00 grade point average in upper division technical course work.

(3) The final 30 units are completed in residence in the College of Engineering on the Berkeley campus in two consecutive semesters.

Humanities and Social Sciences. To promote a well-rounded education with foundations in the liberal arts, the College has established a humanities and social sciences requirement. The skills learned in the humanities and social sciences supply students with additional tools to help them succeed in their intended engineering fields.

The requirement includes two approved *reading and composition* courses and four additional approved courses, with which a number of specific conditions must be satisfied. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

Academic Rules and Regulations

Absence from the University. Students returning after an absence from the University must meet the current curriculum requirements at the time of readmission. See the Admission section for more information.

Scholarship Requirements. (1) Students are subject to dismissal if they (a) do not have a minimum C average for all work undertaken at the University; (b) do not obtain a minimum C average in each semester.

(2) Students must have a minimum C average in all upper division technical courses required and elected in the major curriculum in order to obtain the bachelor's degree.

Passed/Not Passed Grades. Students in good standing may undertake certain elective courses on a passed/not passed basis. These courses are not included in determining grade point average. No technical courses (mathematics, science, or engineering) may be taken on a passed/not passed basis. No more than 1/3 of a student's total units at UC Berkeley may be taken passed/not passed. There is no limit in any one semester on the number of units that can be taken passed/not passed.

Upper Division. Students are expected to complete the lower division program before enrolling in upper division engineering courses. Exceptions may be made if the lower division deficiency is not a prerequisite to the intended upper division course and if the lower division program is being completed expeditiously.

Normal Progress. Students in the College of Engineering must — except for reasons of health or outside employment — enroll in a full-time program and make normal progress toward the bachelor's degree. The continued enrollment of students who fail to achieve minimum academic progress shall be subject to the approval of the dean. To achieve minimum academic progress, two criteria must be met:

(1) Students must have successfully completed a number of units no fewer than 15 times the number of semesters less one, in which they have been enrolled on the Berkeley campus. Summer Sessions will not be counted as a semester.

(2) Students' study lists must contain at least 12 units of credit in any term. Students' programs must receive the approval of the faculty adviser and must include at least two technical courses related to the chosen curriculum. Students are responsible for planning and satisfactorily completing graduation requirements and should follow, as closely as possible, the curricular recommendations given on the succeeding pages. Program deviations should be discussed with the faculty adviser.

In all cases, students desiring to take more than 20.5 units or fewer than 12 units per semester must have prior approval of the dean.

The minimum unit requirement for the bachelor's degree is 120 semester units, within which the student is expected to satisfy graduation requirements.

Entering freshmen are allowed eight semesters to graduate, and entering junior transfers are allowed four semesters to graduate. Students who need one extra semester to graduate must petition to do so. If the associate dean grants an extra semester, the student will be required to enroll in at least 12 units *and two technical courses* in that extra semester.

Honors. (1) *Honors to Date.* Students must have completed a minimum of 12 units undertaken for letter grades on the Berkeley campus to be considered for the award of semester honors. To qualify for this award, students must achieve a grade point average equal to or greater than the grade point average as determined for the College by the method outlined below. This honor is noted on the student's transcript.

(2) *Honors in General Scholarship at Graduation.* To be eligible for honors in general scholarship at graduation, students must have: (a) completed at the University of California a minimum of 50 semester units, of which at least 43 units must be undertaken for a letter grade; for those students who complete more than 50 units at the University of California, the limit of passed/not passed units is 1/3 of the total units undertaken and passed on the Berkeley campus at the time the degree is awarded; units completed in an Education Abroad Program, or on another University of California campus by an undergraduate in an Intercampus Visitor Program, are considered Berkeley work for the purpose of this regulation (204-A); (b) completed a minimum of 30 units on the Berkeley campus; and (c) achieved a grade point average ranking in the College as follows:

- Top 3 percent, highest honors
- Next 7 percent, high honors
- Next 10 percent, honors

At the end of each academic year, the Office of the Registrar determines for the College the minimum grade point averages of the top three percent, the next seven percent, and the next 10 percent of the students graduating in that year. These grade point averages serve the College as minimal criteria for honors during the next academic year. Students should consult Engineering Student Services to learn the minimum grade point averages in effect for the current academic year.

▲ ***Attendees of the College of Engineering New Student Orientation watch future classmates learn to juggle the many tasks involved in college life, each represented by a balloon, in an activity entitled "High School Is Over."***

Students should get comfortable in their seats: the orientation takes place in Pimentel Hall, where they may find themselves taking their introductory science courses. The hall is equipped with a revolving stage, so that it can be used continuously despite long setup times for science lectures.

Graduate Admission and Degree Requirements Online Resources

For more information on the topics in this section, please see the following websites:

UC Berkeley General Catalog:
catalog.berkeley.edu

Graduate Division (Admission, Financial Aid, Academic Policies):
grad.berkeley.edu

Guide to Graduate Policy (Graduate Division):
grad.berkeley.edu/policies/guide.shtml

Guide to Graduate Program Rules and Regulations (College of Engineering):
coe.berkeley.edu/graduate-guide

Graduate Programs

The principal objectives of graduate study in engineering are:

(1) To provide students with the scientific and professional knowledge necessary for their fields of interest.

(2) To develop students' abilities to formulate solutions to new and complex problems in their fields in the context of current economic, sociological, and environmental considerations.

These objectives are accomplished by providing flexible programs of study designed to meet individual student needs.

Programs

The College offers programs of study in seven departments:

- Bioengineering
- Civil and Environmental Engineering
- Electrical Engineering and Computer Sciences
- Industrial Engineering and Operations Research
- Materials Science and Engineering
- Mechanical Engineering
- Nuclear Engineering

In addition to the departmental majors, the College offers two interdisciplinary programs leading to the following degrees:

- Ph.D. degree in applied science and technology.

- Ph.D. degree in bioengineering, a joint degree program with the University of California, San Francisco.

Concurrent degree programs that provide a broad integrated curriculum between two disciplines are:

- Architecture, M.Arch. — Civil and Environmental Engineering (Structural), M.S.

- City and Regional Planning, M.C.P. — Civil and Environmental Engineering (Transportation), M.S.

- Public Policy, M.P.P. — various Engineering, M.S.

Interdisciplinary Programs

The College also offers a number of interdisciplinary programs in which graduate study is related to the work of faculty in more than one engineering department and may include faculty and students from other areas of the University. These programs relate the application of technical, social, and economic knowledge to the analysis and solution of engineering problems. The following graduate interdisciplinary programs are available. Interested applicants should contact the department/unit indicated with the program: applied science and technology (College of Engineering); computational science and engineering (College of Engineering); environmental (Civil and Environmental Engineering); engineering and business administration (Mechanical Engineering or Business Administration); nanoscale science and engineering (Nanoscale Science and Engineering Graduate Group, Applied Science and Technology, Materials Science and Engineering, et al.); plasmas (Electrical Engineering and Computer Sciences); robotics and manufacturing (Electrical Engineering and Computer Sciences or Mechanical Engineering); rock mechanics (Civil and Environmental Engineering or Mechanical Engineering); surface and subsurface hydrology (Civil and Environmental Engineering, Materials Science and Engineering, or Mechanical Engineering).

College Certificate Programs

- **Intelligent Transportation Systems** — being established jointly by the Departments of Civil and Environmental Engineering, Mechanical Engineering, and Electrical Engineering and Computer Sciences. This certificate is not issued by the University of California, Berkeley.

- **Logistics** — offered jointly by the Departments of Industrial Engineering and Operations Research and Civil and Environmental Engineering (see pages 19 and 31). This certificate is not issued by the University of California, Berkeley.

- **Energy and Business for Sustainability** — offered in conjunction with the Haas School of Business, Energy and Resources Group, Goldman School of Public Policy, College of Natural Resources, and School of Public Health. It is the first certificate program approved at the highest campus level.

- **Management of Technology (MOT)** — jointly sponsored by the College, the Haas School of Business, and the School of Information. This certificate is not issued by the University of California, Berkeley.

The Management of Technology (MOT) Certificate Program was established in 1987 as a research and teaching program that seeks to bring together faculty and students to address critical technology management issues. The certificate program is open to all graduate students enrolled in the Haas School of Business, College of Engineering, or other departments, and it allows students to specialize in the management of technology as they obtain their degrees. There is no separate admissions process for the MOT program. Once enrolled, students are eligible to take courses leading to a Certificate in Management of Technology. For information, contact the Management of Technology Certificate Program; 462 Sutardja Dai Hall; University of California, Berkeley; Berkeley CA 94720-1758; telephone: (510) 642-4205; email: motadmin@haas.berkeley.edu; website: mot.berkeley.edu.

Admission

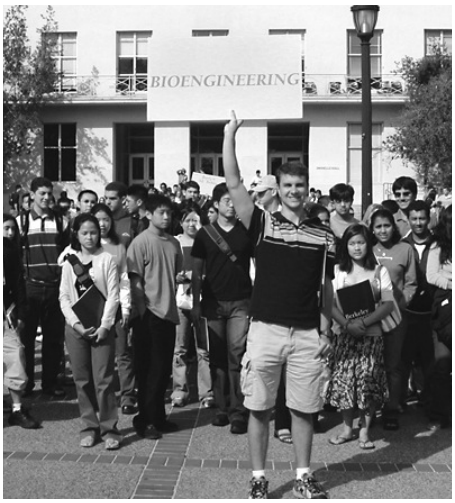
Students admitted by the Graduate Division of the University to graduate study in engineering, including those interested in multidisciplinary programs, must be accepted by one of the engineering departments. Students must state on the admission application the department and the program of study they desire.

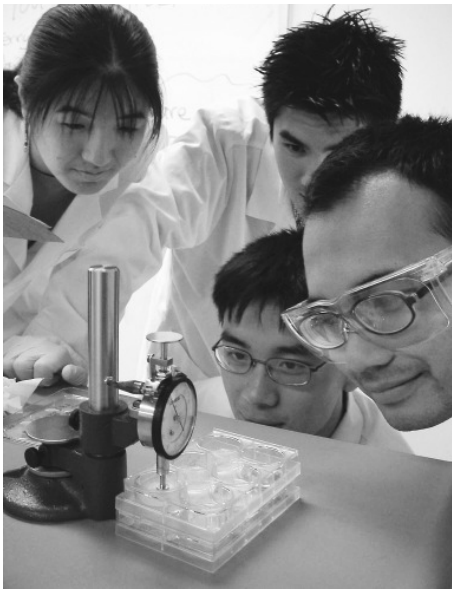
Application for Admission. All necessary applications and information on graduate programs and department application deadlines are available at the department of interest. Prospective graduate students wishing to participate in an interdisciplinary program should apply for admission to one of the departments of the College or to the Graduate Group in Applied Science and Technology or the Joint UCSF/UCB Graduate Group in Bioengineering. Students with an interest in Management and Technology may apply to Business Administration. See the *General Catalog,* the Graduate Division and your department of interest for details on admission requirements, deadlines, and financial support.

Graduate Student Instructorships and Graduate Student Researchships. Graduate student instructorships (GSIs) and graduate student researchships (GSRs) are available to qualified graduate students. Graduate student instructors and researchers must carry a study program of at least 12 units. Students interested in these positions should indicate this in the department admission application.

Requirements for Higher Degrees

For information on degree requirements and regulations, see the Graduate Division's *Guide to Graduate Policy*. Requirements and regulations specific to the College of Engineering can be found in College's companion publication, *Guide to Graduate Program Rules and Regulations.*





▲ ***Sutardja Dai Hall houses CITRIS and the Banatao Institute @ CITRIS Berkeley, dedicated to creating information technology solutions for the world's most pressing social, environmental, and health care problems.***

Academic Departments and Programs

Bioengineering

306 Stanley Hall #1762
(510) 642-5833
bioeng.berkeley.edu
Chair: Matthew Tirrell, Ph.D.

Department Overview

Established in 1998, the Department of Bioengineering at UC Berkeley applies engineering principles and practices to living things, integrating biological and medical sciences with advanced technology to help people live longer and healthier lives.

No other field fulfills the potential for interdisciplinary research and education more than bioengineering. Our work is concentrated on high-impact applications in molecular and cellular engineering that will bring about major advances in medicine and the life sciences. We anticipate future breakthroughs ranging from the design of drugs customized to an individual's genome to tiny implantable drug delivery devices, to software and components that allow researchers to design bacteria like electronic circuits.

Research efforts in the Department of Bioengineering are organized around five focus areas: Cell and Tissue Engineering, Biomaterials and Nanotechnology, Bioinstrumentation, Computational Biology, and Systems and Synthetic Biology. The department offers students the opportunity to work with outstanding faculty in these areas, plus the freedom to pursue studies with world-class faculty in related areas of interest. This unique environment for learning and research in a rapidly growing discipline provides dedicated students with the foundation required to become leaders in the field of bioengineering.

The Department of Bioengineering at UC Berkeley is supported by exceptional faculty, strong ties to other departments on campus, and close collaborations with other institutions like UC San Francisco and Lawrence Berkeley National Laboratory. We continue to expand our department with new faculty, staff, facilities, and research programs, and we are coordinating a broad range of bioengineering-related activities currently underway on campus.

Undergraduate Program

The multidisciplinary undergraduate major in bioengineering is intended for academically strong students who excel in the physical sciences, mathematics, and biology. It offers students an opportunity to learn how to apply the physical sciences and mathematics in an engineering approach to biological systems. The undergraduate curriculum is designed to ensure that students will be well grounded in the fundamental principles and methods of engineering, as well as in integrative and molecular biology. There are further opportunities for specialization in advanced areas of both engineering and biology, including laboratory and clinical components. Bioengineering graduates may enter industry, go on to medical school, and/or pursue graduate studies in bioengineering and related disciplines.

See undergraduate sample curricula on page 15 for more information on the undergraduate program requirements and concentrations.

Bioengineering Minor

The department offers a minor in bioengineering that is open to all students not majoring in bioengineering who have completed the necessary prerequisites for the minor requirements. Information is available in the Student Services Office, 306 Stanley Hall.

Joint Major Program in Bioengineering and Materials Science and Engineering

The department offers a joint major program with the Department of Materials Science and Engineering. See the "Joint Majors" section of this announcement for a detailed description and curriculum.

Berkeley Summer Bioengineering Research Program

Established in 2000, the Berkeley Summer Bioengineering Research Program provides intensive laboratory research experience to promising undergraduates. After a competitive application process, selected students are supported by a stipend while performing full-time research in faculty laboratories for 10 weeks during the summer. The intensive experience allows students to devote themselves to the project and learn a lot in a short time. Many continue to do research with their faculty mentors into the fall. More information is available at bioeng.berkeley.edu/bsbrp.

Graduate Study

The Ph.D. and Master of Science in bioengineering are jointly offered by UC Berkeley and UC San Francisco (UCSF).

The Joint Graduate Group in Bioengineering is an interdisciplinary program that combines the resources in biomedical sciences at UCSF with the excellence in engineering, physical, and life sciences at UC Berkeley. With over 140 faculty members from many departments on the two campuses, our program offers unmatched graduate training opportunities in bioengineering. Students in the program may take courses and perform research on either or both campuses.

Students with a B.A. or B.S. degree in engineering, biology, or other related fields are eligible for admission. Students can obtain additional information and application materials by contacting the Bioengineering Graduate Program, Department of Bioengineering, 306 Stanley Hall, University of California, Berkeley; Berkeley, CA, 94720-1762; (510) 642-9931; bioegrad.berkeley.edu.

Facilities

Laboratory research is an important component of the bioengineering educational program. Numerous undergraduate and graduate research opportunities are made possible in laboratory facilities located at the Berkeley campus, the UCSF campus, and Lawrence Berkeley National Laboratory (LBNL).

Most core bioengineering faculty have laboratories in Stanley Hall (see page 47 for photo), a new interdisciplinary science and engineering building recently completed at Berkeley. Housing research groups from the Departments of Bioengineering, Chemistry, Molecular and Cell Biology, and Physics, the new Stanley Hall was designed to foster collaboration among faculty and students who do research at the intersection of the biological and physical sciences and engineering. The eight-floor, 285,000 square-foot building is also home to the Department of Bioengineering offices, teaching labs, the Biomolecular Nanotechnology Center, and other multi-user facilities. Bioengineering students have access to a number of specialized laboratories that reflect the breadth of research activities in the department, either in Stanley Hall or other buildings in close proximity on the Berkeley campus. More information about labs and facilities can be found on the Department of Bioengineering website.

▲ ***Bioengineering Vice-Chair of Instruction Steve Connolly congratulates a recent graduate during the May commencement ceremonies. Engineering faculty in all departments work closely with both undergraduate and graduate students in research and career and course planning.***

Undergraduate Program in Bioengineering*		120-125 Units
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
Chemistry 3A and 3AL – Chemical Structure and Reactivity Chemistry 112A – Organic Chemistry[1]	-	5
E 10 – Engineering Design and Analysis BioE 10 – Introduction to Biomedicine for Engineers	3-4	-
E 7 – Introduction to Computer Programming for Scientists & Engineers CS 61A – Structure and Interpretation of Computer Programs	-	4
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Seminar: BioE 24 – Aspects of Bioengineering BioE 25 – Careers in Biotechnology[2]	1	1
Reading and Composition Course from List A[3]	4	-
Total	**16-17**	**18**
Sophomore Year		
Biology 1A and 1AL – General Biology	-	5
Chemistry 3B – Chemical Structure and Reactivity Chemistry 112B – Organic Chemistry[4]	3	-
Engineering/Biology Preparation[5]	3	3
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Reading and Composition Course from List B[2,3]	-	4
Total	**14**	**16**
Junior Year		
Bioengineering Fundamentals (see concentrations for recommendations)[6]	4	4
Engineering Topic (see concentrations for recommendations)[7]	3	-
Technical Electives (see concentrations for recommendations)[8]	4	3
Upper division biology elective (see concentrations for recommendations)[9]	-	3
First Additional Humanities/Social Sciences Course[2,3]	3-4	-
BioE 100 – Ethics in Science and Engineering Second Additional Humanities/Social Sciences Course (with Ethics Content)[3,4]	-	3-4
Total	**14-15**	**13-14**
Senior Year		
Bioengineering Lab Course	4	-
Bioengineering Topics (see concentrations for recommendations)[10]	4	4
Engineering Topic (see concentrations for recommendations)[7]	-	4
Technical Elective (see concentrations for recommendations)[8]	3	-
Bioengineering Design Project or Research[2]	-	4
Third and Fourth Additional Humanities/Social Sciences Courses[2,3]	3-4	3-4
Total	**14-15**	**15-16**

[1] Chemistry 112A/B is intended for students majoring in chemistry or a closely related field and is more intensive than Chemistry 3A/3B. **Note:** Prerequisites to Chemistry 112A/B include Chemistry 1A and Chemistry 1B (or Chemistry 4A and Chemistry 4B).

[2] This requirement may be completed at any time in the program.

[3] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses. Consult the "Ethics Content List" on the following page for courses with ethics content.

[4] Pre-Med students should take Chemistry 3B and 3BL or Chemistry 112B and Biology 1B.

[5] Select two from the Engineering/Biology Preparation list.

[6] Choose courses from the approved Bioengineering Fundamentals list.

[7] Choose courses from the approved Engineering Topics list.

[8] Choose courses from the approved Technical Elective list.

[9] Choose courses from the approved Upper Division Biology list.

[10] Choose courses from the Bioengineering Topics list.

***** Program of study must include:

(a) 42 units of upper division coursework in technical subjects such as engineering, chemistry, physics, integrative biology, molecular and cell biology, mathematics, or statistics. Of these units, at least 22 must be in bioengineering. The 42 units must be from the bioengineering core curriculum (excluding BioE 100) or the Curriculum Electives lists.

(b) 45 units of engineering (upper or lower division). These units must be from courses that appear on the Bioengineering Topics or Engineering Topics lists.

Students are advised to consult the approved concentrations to identify an appropriate course sequence for bioengineering specialty areas, and may also design their own program that meets with the above requirements with permission from their faculty adviser. Regular consultation with an adviser is strongly recommended.

Curriculum Electives Lists

When planning your program, please note that you're are required to include the following:

(a) 42 units of upper division coursework in technical subjects such as engineering, chemistry, physics, integrative biology, molecular and cell biology, mathematics, or statistics. Of these units, at least 22 must be in bioengineering. The 42 units must be from the bioengineering core curriculum (excluding BioE 100) or the Curriculum Electives Lists.

(b) 45 units of engineering (upper or lower division). These units must be from courses that appear on the Bioengineering Topics or Engineering Topics lists.

Bioengineering Fundamentals:
BioE 101, 102, 104, 110, 116, 131, 150

Bioengineering Topics:
BioE 22 and 22L, 101, 102, 104, C105B, 110, 111, 112, 113, 115, 116, C117, C118, C119, 121, 121L, C125, 131, 135, C136L, C140L, C141, 142, 143, C144, C144L, C145L, C145M, C146, 150, 151, 164, C165, 168L, 190A-H.

Engineering Topics:
BioE 192, H194, 196; Chem E 140, 141, 150A, 150B, 170A, 170B, 171, C178; CE C30/ME C85; CE 130N; CS 61A, 61B or 61BL, 70, 170, 186, C191; E 7, 45, 115, 170; EE 20N, 40, 100, 105, 117, 120, 126, 129, 142, 143, 192; IEOR 162; ME 102B, 104, 106, 109, 118, 119, 128, 132, 133, 167, 185; MSE 102, 104, 111, 113, 151; NE 101, 107, 170B. Also includes any course from the BioE Topics list.

Technical Electives:
Biology 1B; Chemistry 120A, 120B, C130/MCB C100A, 130B; CS 61B or 61BL; IEOR 172 (or Statistics 134); Math 55, 110, 118, 127, 128A, 170; Nutritional Science and Toxicology 121; Physics 7C, 110A, 112, 137A, 177, C191; Public Health 143; Statistics 133, 134 (or IEOR 172), 135, 150. Also includes any course from the Bioengineering Topics, Engineering Topics, or Upper Division Biology lists.

Upper Division Biology:
Integrative Biology 115, 127 and 127L, 131, 132, 148; Chemistry C130, 135; MCB C100A, 100B, 102, 110, 111, 130A, 132, 133L, 136, 140, 140L, C145, C148, 150, C160/Neuroscience C160, 160L, 166; Plant and Microbial Biology 185.

Bioengineering Lab Courses:
BioE 22 and 22L, 115, 121L, C136L, 140L, C144L, C145L, C145M, 168L

Engineering / Biology Preparation:
BioE C105B; E 45; EE 20N, 40 or 100; CS 61B or 61BL; Chemistry 120B, C130/MCB C100A.

Bioengineering Design Project and Research:
BioE 121L, 140L, 168L, 192, H194, 196

Bioengineering Ethics Content List:
(these courses do not count toward engineering or upper division technical units.)

Fulfills <u>both</u> Humanities/Social Sciences (H/SS) and Ethics Content: Anthropology 156B; BioE 100; E 124, 195; Environmental Science, Policy, and Management 161, 162; Letters and Science 160B; Philosophy 2, 104, 107.
Fulfills Bioengineering Ethics Content requirement <u>only</u>: E 191, Public Health 116

Bioengineering Concentrations

Students are advised to consult the approved concentrations to identify an appropriate course sequence for bioengineering specialty areas. Students may also design their own program that meets all of the bioengineering requirements with permission from their faculty adviser. Regular consultation with an adviser is strongly recommended.

See bioeng.berkeley.edu/curriculum for curriculum diagrams for each concentration.

Recommended Courses:

I. Biomaterials:

Engineering/Biology Preparation: E 45; Chemistry C130/MCB 100A

Bioengineering Fundamentals: BioE 102, 104

Engineering Topics: MSE 102 (Junior), MSE 104

Bioengineering Topics: BioE C118 and BioE 116 or 150

Technical Electives: Statistics 134 or EE 126 (Junior); ChemE 178 and BioE Topic or Eng Topic course

Upper Division Biology: from approved list

Bioengineering Lab Course: from approved list

II. Biomechanics:

Engineering/Biology Preparation: EE 100; Chemistry C130/MCB 100A

Bioengineering Fundamentals: BioE 101, 102

Engineering Topics: ME C85, 104

Bioengineering Topics: BioE 112 and 116

Technical Electives: ME 106; Statistics 134 or EE 126 (Junior); from approved list

Upper Division Biology: from approved list

Bioengineering Lab Course: upper division from approved list

III. Biomedical Devices:

Engineering/Biology Preparation: E 45 and EE 100

Bioengineering Fundamentals: BioE 102, 104

Engineering Topics: ME C85, 106

Bioengineering Topics: BioE 121 and 151 or 164

Technical Electives: BioE 22 and 22L (Junior); BioE 101, C118 or 150 and Statistics 134 or EE 126 (Senior)

Upper Division Biology Elective: MCB C100A

Bioengineering Lab Course: BioE 121L

IV. Cell and Tissue Engineering:

Engineering/Biology Preparation: EE 100; Chemistry C130/MCB C100A

Bioengineering Fundamentals: BioE 102, 104

Engineering Topics: BioE C118, 135 and/or 150; E45 or BioE 101

Bioengineering Topics: BioE 113 and 116

Technical Electives: Statistics 134 or EE 126 (Junior); from approved list

Upper Division Biology: from approved list

Bioengineering Lab Course: BioE 115 or 140L

V. Computational Bioengineering:

Engineering/Biology Preparation: Chemistry C130/MCB C100A (Sophomore); CS 61B, E 45 or EE 100 (Junior)

Bioengineering Fundamentals: BioE 131

Engineering Topics: BioE 102 and 112 or 135

Bioengineering Topics: BioE 143, C144

Technical Electives: from approved list, see website for suggestions

Upper Division Biology Elective: MCB 110

Bioengineering Lab Course: BioE C144L

VI. Imaging:

Engineering/Biology Preparation: EE 20N, 100

Bioengineering Fundamentals: BioE 101, 110

Engineering Topics: BioE 22/22L; Bioe 102 and/or 131

Bioengineering Topics: BioE 164 and C165

Technical Electives: EE 120 and Statistics 134 or EE 126 (Junior), any from approved list (Senior)

Upper Division Biology Elective: MCB C100A/Chemistry C130

Bioengineering Lab Course: BioE C145L, C145M or 168L

VII. Pre-Med:

Engineering/Biology Preparation: Chemistry C130/MCB C100A; E 45 or EE 100 (Sophomore)

Bioengineering Fundamentals: BioE 102, 110

Engineering Topics: from approved list

Bioengineering Topics: from approved list

Technical Electives: Biology 1B; Statistics 134 or EE 126 (Junior), from approved list (Senior)

Upper Division Biology Elective: from approved list

Bioengineering Lab Course: upper division from approved list

Civil and Environmental Engineering

760 Davis Hall #1710
(510) 642-3261
www.ce.berkeley.edu
Chair: Lisa Alvarez-Cohen, Ph.D.

Department Overview

Civil and environmental engineers design, construct, and maintain the built environment in which we live and work. Projects range from the tallest skyscrapers and soaring bridge spans to tunnels and underground structures. Our graduates work to ensure efficient transportation of people and goods on the highway system, by rail, by ship, and by air. We manage scarce water and groundwater resources, and we design and operate systems to protect public health, water quality, and the environment. We use modern materials and system analysis methods to manage and renew the civil infrastructure. Computing and information technology tools make it possible to sense the condition of the infrastructure, and then to communicate and rapidly respond to disruptions in normal operations. High-performance computing is used to simulate the behavior of complex civil systems, visualize the results, and optimize management strategies.

Demands for improvements to civil infrastructure are ever-present, because of population growth and deterioration of existing systems over time. Infrastructure must be designed and managed to minimize impacts on the environment. Our infrastructure also must be protected against natural and man-made hazards such as earthquakes, landslides, floods, fires, and explosions.

The program in civil and environmental engineering at UC Berkeley, which is top-ranked nationally, combines fundamental science with modern engineering to address societal needs.

Undergraduate Program

The mission of the Civil Engineering B.S. degree program is to educate engineering leaders who will contribute to solving societal problems by improving the civil infrastructure, resource protection, natural hazard mitigation, and the efficient and sustainable functioning of engineered and natural systems in California, the United States, and worldwide.

To achieve the missions of the College of Engineering and the Department of Civil and Environmental Engineering (CEE), the department faculty have established the following Program Educational Objectives for the B.S. degree:

(1) To prepare graduates to pursue post-graduate education in engineering or other professional fields.

(2) To prepare graduates to become licensed professional engineers.

(3) To prepare graduates to become leaders in the civil and environmental engineering profession.

Undergraduates at Berkeley have opportunities for professional interactions and community service. CEE has active student chapters of the American Society of Civil Engineers and the national honor society of Chi Epsilon. Additional student societies and clubs are available on campus for students to develop leadership skills and engage in professional and social interactions.

The civil engineering undergraduate program is accredited by Engineering Accreditation Commission of the ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; (410) 347-7700.

Civil Engineering Areas of Emphasis

Students with a specific interest within civil engineering may choose to emphasize one of the areas listed in the civil engineering undergraduate program curriculum grid at the end of this section. For each area of emphasis, suggestions are listed for elective courses and the capstone design project.

Selection of an area of emphasis is optional. A bachelor of science in engineering is awarded whether or not a student follows the broad and general program or chooses an area of emphasis.

Non-technical electives may fulfill the degree's humanities/social sciences requirement. (Please refer to the handout at coe.berkeley.edu/hssreq or in 230 Bechtel Engineering Center.) Students may also take the eight units of credit required to earn a Certificate in Management of Engineering and Innovation offered through the College of Engineering's Center for Entrepreneurship and Technology.

Civil Engineering Minors

The department offers three minors: environmental engineering, structural engineering, and geoengineering. These minors are open to all students who are not majoring in civil engineering and who have completed the necessary prerequisites. Information is available in the Civil and Environmental Engineering Student Affairs Office, 750 Davis Hall, and on the department website.

Graduate Study

The Civil and Environmental Engineering Department administers graduate programs that lead to both academic (Master of Science and Doctor of Philosophy) and professional (Master of Engineering) degrees in the major areas of professional specialization.

Engineering and Project Management

The objective of the engineering and project management program is to educate professionals for leadership in corporate and project

management, research, and teaching associated with the lifecycle of civil engineered systems. Teaching and research are organized around seven areas of emphasis: business management and leadership; human and organizational considerations; quality and reliability assessments; lifecycle engineering and management processes; production and construction engineering; engineering and the environment; and implementation processes and strategies.

Because of the broad and interdisciplinary nature of this area of study, students are encouraged to pursue advanced and relevant coursework in all of the department's and college's programs, and other campus programs, such as architecture, business, public policy, management of technology, and logistics.

Environmental Engineering

Environmental engineers apply science and technology to manage water and air resources and to control contaminants that threaten environmental quality. This program recognizes that engineering solutions to the challenges of human health and ecosystem protection require a broad-based approach to teaching and research. Because of the complex nature of these issues, education in preparation for professional practice is accomplished primarily at the graduate level. Students should have a solid undergraduate foundation in the engineering sciences.

Areas of emphasis include the improvement of indoor and atmospheric air quality; conventional and natural processes for treatment processes of drinking water, wastewater, and hazardous wastes; quantification of contaminant transport processes in multimedia environments; soil chemistry, photochemical transformations, subsurface thermal and biological remediation technologies; identification and restoration of degraded ecosystems; surface and groundwater hydrology; hydrologic mixing processes; climate variability and change; water resources management; environmental fluid mechanics; and coastal zone processes in estuaries and shorelines.

Geoengineering

The graduate program in geoengineering offers a full complement of education and research opportunities in the traditional geotechnical areas of soil mechanics, foundation engineering, earthquake engineering, geological engineering, underground construction, and rock mechanics, as well as in the emerging areas of environmental geotechnology, including groundwater hydrology, contaminant transport, and geotechnical aspects of waste disposal, clean up, and containment. In addition, this program offers both educational and research opportunities in the area of engineering geophysics. Opportunities for interdisciplinary studies are provided through close interaction in teaching and research with other areas of engineering, geology (and geophysics), seismology, and soil science.

Structural Engineering, Mechanics, and Materials (SEMM)

SEMM at Berkeley has programs in the fields of structural engineering, structural mechanics, and civil engineering materials. The programs are founded on rigorous principles and methods with application to engineering challenges in today's world. The master's degrees (M. Eng. and M.S.) provide an advanced education for a life-long career in professional practice or preparation for doctoral studies. The doctoral degree provides opportunities for careers in academic research and teaching, applied research, or advanced professional practice. Broad areas of graduate study within SEMM include earthquake engineering, including modern performance-based approaches; structural design, materials, and construction; hybrid experimental simulation of structures; computational structural analysis and dynamics; structural and geotechnical engineering; theoretical, structural, and computational mechanics; high-performance structural materials; information technologies in structural and civil engineering; reliability and risk engineering; and civil systems engineering.

Transportation Engineering

The graduate program in transportation engineering offers courses in analysis techniques, planning methods, systems operations, design, systems engineering, management, economics, administration, and policy. Students have the opportunity to study in one of the world's leading centers for transportation research, education, and scholarship. Research areas include transportation, including aviation and airport design and operation, intelligent transportation, transit, traffic safety, transportation finance, transportation economics, infrastructure design and maintenance, traffic theory, public policy, logistics, systems analysis, and environmental policy.

The Institute of Transportation Studies (ITS) on the Berkeley campus provides students with a stimulating research environment and one of the world's leading transportation libraries. ITS's research program presents many opportunities for qualified students to obtain part-time employment.

Civil Systems

Many civil and environmental engineering problems involve large systems, such as transportation systems, environment systems, and metropolitan or national infrastructures, that operate as a network of complex and interrelated components. Innovative solutions often require a combination of domain knowledge, systems analysis, new technologies, economics, and management science that is rarely found in traditional disciplines alone.

The purpose of the Civil Systems program is to prepare students who can address the broad challenges of the future with relevant knowledge and skills. Civil Systems is a multidisciplinary program made up of students with degrees in a wide range of engineering and science disciplines, including civil and environmental engineering. The guidelines for the Ph.D. coursework and research are flexible while maintaining intellectual rigor. The program provides the opportunity for in depth knowledge in one or more specialties important for understanding civil and environmental systems. Students may enter the systems program with a Bachelor of Science or a Master of Science degree.

Concurrent Degrees and Certificate Programs

The Department of Civil and Environmental Engineering offers three concurrent degree programs: Structural Engineering and Architecture (M.Arch/M.S.), Transportation Engineering and City and Regional Planning (M.C.P./M.S.), and any civil and environmental engineering program and Public Policy (M.P.P./M.S.).

CEE offers three certificate programs: the Certificate in Management of Technology Program (MOT) that is offered in conjunction with the Haas School of Business and the School of Information; the Certificate in Logistics that is offered in conjunction with the Department of Industrial Engineering and Operations Research; and the Certificate in Engineering and Business for Sustainability that is offered in conjunction with the College of Engineering, the Haas School of Business, the College of Natural Resources, and the Schools of Public Health and Public Policy.

Facilities

Facilities for advanced study and research are located on the Berkeley campus, at Lawrence Berkeley National Laboratory and the Richmond Field Station.

Students and faculty in the department are supported by a range of outstanding research facilities, including laboratories in structures and materials, environmental water resources, environmental quality, transportation engineering, geoengineering, and earthquake engineering.

Departmental computing facilities include multiple instructional computing labs featuring high performance networked Windows workstations running advanced engineering applications, servers for centralized file storage and backup, and high-speed wired and wireless networks for data sharing. Additional computing resources are made available by research groups.

See the department website for more information on CEE research and facilities.

Undergraduate Program in Civil Engineering		118-125 units*
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 10 – Engineering Design and Analysis	3	-
E 7 – Introduction to Computer Programming for Scientists & Engineers	-	4
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
CE 92 – Introduction to Civil and Environmental Engineering[3]	<1>	<1>
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B	-	4
Total	**15-16**	**16-17**
Sophomore Year		
Basic Science Elective[2]	-	4
CE C30/ME C85 – Introduction to Solid Mechanics	-	3
CE 60 – Structure and Properties of Civil Engineering Materials	3	-
CE 93 – Engineering Data Analysis	-	3
Engineering Science and Sustainability Elective[2]	-	3
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
First Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**14-15**	**17**
Junior Year		
CE 100 – Elementary Fluid Mechanics	4	-
CE 130N – Mechanics of Structures	-	3
Elective Core[4]	6	6
Engineering Science Elective[2]	-	3
Second and Third Additional Humanities/Social Sciences Course[1]	3-4	3-4
Total	**13-14**	**15-16**
Senior Year		
CE 192 – The Art and Science of Civil and Environmental Engineering Practice	-	1
Design Elective[2]	-	3-4
Engineering Electives[5]	15	-
Fourth Additional Humanities/Social Sciences Course[1]	-	3-4
Free Electives	-	5-7
Total	**15**	**12-16**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] See the Elective Courses list. Choose one under this category.

[3] Can be taken either fall or spring.

[4] See the Elective Courses list. Choose four under this category.

[5] Engineering electives must include at least 15 additional units of upper division technically oriented engineering coursework offered in the College of Engineering or in Chemical Engineering. The 15 units of engineering electives cannot include: any course taken on a P/NP basis; BioE 100; CS 194, C195; E C111, 191, 193, 196; EE 194; IEOR 172, 190 series; ME 106.

***A minimum of 120 units is required for graduation.**

Elective Courses List

Basic Science:
Chemistry 1B, 4B; Physics 7C

Engineering Science and Sustainability:
CE 11, 70

Core:
CE 103, 111, 120, 155, 167, 175, 191

Engineering Science:
E 115; ME 40, 104, C105B

Design:
CE 112, 122, 123, 153, 177, 180

Areas of Emphasis

Students with a specific interest within civil engineering may choose to emphasize one of the areas listed below. Selection of an area of emphasis is optional.

Recommended Courses:

Engineering and Project Management:
Elective Core: CE 120, 167
Design Course: CE 180
Technical Electives: CE 165, 166, 171, 173, 176, 191, 193; E 190
Suggested non-technical electives: UGBA 101A, 101B, 103, 106, 107

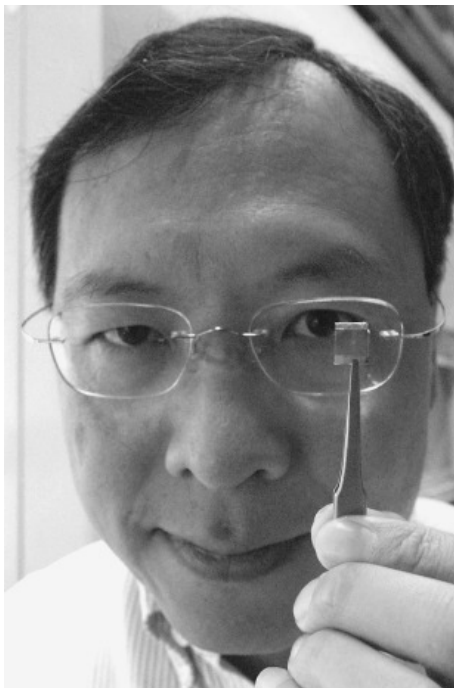
Environmental Engineering:
Elective Core: CE 103, 111
Design Course: CE 112
Technical Electives: CE 101, C106, 107, 108, 113N, 114, 115, C116, 173, 176, C178; E 190; ME 109, 146; MSE 112; NE 124
Suggested non-technical electives: Biology 1B; Energy and Resources 100; Integrative Biology 153

GeoEngineering:
Elective Core: CE 111, 120, 175
Design Course: CE 177
Technical Electives: CE 103, 115, 121, 122, 123, 124, 167, 171, 172, 173, 176, C178; E 190

Structural Engineering:
Elective Core: CE 120, 167, 175
Design Course: CE 122 or 123
Technical Electives: CE 121, 124, 131, C133, 140, 165, 177, 193; E 190
Note: CE 121 is required for admission for graduate study in Structural Engineering, Mechanics and Materials

Transportation:
Elective Core: CE 155, 191
Design Course: CE 153
Technical Electives: CE 108, 156, 167, 177, C250N, 251, 259, 260; E 117, 190; IE 153
Suggested non-technical electives: City and Regional Planning 110; Economics 101A, C125, 155; Energy and Resources 100; Geography C188; Public Policy 101

Note: Undergraduates wishing to enroll in graduate courses must have the consent of the instructor.



Electrical Engineering and Computer Sciences

Center for Student Affairs
205 Cory Hall #1770
(510) 642-7372 (undergraduate)
(510) 642-3068 (graduate)
eecs.berkeley.edu
Chair: Stuart Russell, Ph.D.

Department Overview

UC Berkeley's Department of Electrical Engineering and Computer Sciences (EECS) offers one of the strongest research and instructional programs in this field anywhere in the world. Our key strength is in our cross-disciplinary team-driven projects. The integration of electrical engineering (EE)[1] and computer science (CS)[2] forms the core, with strong interactions that extend into biological sciences, mechanical and civil engineering, physical sciences, chemistry, mathematics, and operations research. Our programs have been consistently ranked in the top three nationwide and worldwide by various organizations that rank academic programs.

The mission of the EECS department has three parts: (1) educating future leaders in academia, government, industry, and entrepreneurial pursuit, through a rigorous curriculum of theory and application that develops the ability to solve problems, individually and in teams; (2) creating knowledge of fundamental principles and innovative technologies, through research within the core areas of EECS and in collaboration with other disciplines, that is distinguished by its impact on academia, industry, and society; and (3) serving the communities to which we belong, at local, national, and international levels, with a deep awareness of our ethical responsibilities to our profession and to society.

Our strategy to accomplish this mission is simple: recruit and retain the very best faculty, students, and staff, and then empower them to direct and drive the creation and dissemination of knowledge. We know that we have succeeded in this mission when our students succeed, becoming leaders and serving society.

Organizationally, the EECS department smoothly integrates its world class faculty with dedicated staff and extremely active and involved student groups.

[1]Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: (410) 347-7700.

[2]Accredited by the Computing Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: (410) 347-7700.

Undergraduate Programs

Under the auspices of the College of Engineering, EECS offers two undergraduate programs: Electrical and Computer Engineering (ECE) and Computer Science and Engineering (CSE). The CSE program puts a greater emphasis on computer science, whereas the ECE program puts a greater emphasis on electrical engineering. Both programs require the same set of five lower division core courses in EECS (EE 20N, 40; CS 61A, 61B, and 61C) and nearly the same math and science courses. After satisfying program requirements at the lower division level, students are free to choose from a variety of elective upper division courses. To guide students into a coherent choice of courses, we ask students to choose from one of five "options." The choice of option affects the faculty adviser assignment, and the options provide sample programs that suggest reasonable tracks. See the sample programs for more information on the EECS options.

Additional details about the curriculum, requirements, and sample programs that satisfy the requirements can be found in the EECS Undergraduate Notes available online at eecs.berkeley.edu/Programs/Notes/.

Our undergraduate programs recognize the daunting intellectual breadth of the field by offering a great deal of flexibility. These programs are accredited by the Accreditation Board for Engineering and Technology and by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: 410-347-7700.

EECS Options

I. Electronics

This option is for students interested in integrated circuits, electronic devices, nanotechnology, electromagnetics, micro and nano fabrication, photonics and optoelectronics, microelectromechanical systems (MEMS), electronic design automation (EDA), high power circuits, and applications to biomedicine, micro-robotics, sensors, actuators, energy production, storage, and conservation, and silicon structures.

II. Communication, Networks, and Systems

This option is for students interested in networks, control systems, digital and analog communications, information theory, signal processing, and systems modeling, design, verification, and optimization, together with applications to robotics, biomedicine, wireless communications systems, multimedia systems, multi-sensor fusion, and machine intelligence.

III. Computer Systems

This option is for students interested in machine architecture and logic design, communication networks, computer security, operating systems, database systems, programming systems and languages, embedded software, and/or digital devices and circuits, together with applications for networked computing, embedded systems, computer games, and information systems.

IV. Computer Science

This option is for students interested in the foundations of computing, which includes the theory of computation, the design and analysis of algorithms, complexity theory, the architecture and logic design of computers, programming languages, compilers, operating systems, scientific computation, computer graphics, database systems, artificial intelligence and natural language processing, and cryptography and computer security.

V. General Course of Study

This flexible program enables students whose interests are broad or who have yet to focus on a specific field to explore several topics in the areas mentioned above.

EECS Honors Degree Program

The Honors Degree Program is designed to provide very talented undergraduate students with more flexibility at the undergraduate level. Honors students select an academic concentration outside of EECS. In addition, students receive a special faculty adviser, engage in research, receive official notation of the honors degree on their Berkeley transcript, and are invited to special events with faculty and EECS honors alumni. Applications to the Honors Degree Program are accepted at the end of the fall and spring semesters. Typically students apply during their junior year. Visit the EECS Student Affairs Office or www.eecs.berkeley.edu/Programs/honors.html for more information about the program. More information is also available in the *EECS Undergraduate Notes* available online at eecs.berkeley.edu/Programs/Notes/Content/Chapter4.pdf

EECS Minor

The EECS minor, offered through the College of Engineering, is open to any undergraduate who has declared a major on the Berkeley campus, with the exception of EECS majors. It is intended for students who have an interest in electrical engineering and computer science. Students interested only in computer science courses should consider the computer science minor. Applications are accepted throughout the year and are available from the Center for Student Affairs, 205 Cory Hall or eecs.berkeley.edu/Programs/eecsminor.html

Joint Major Programs

The department offers two joint majors with the Department of Materials Science and Engineering and Nuclear Engineering. See the "Joint Majors" section for full descriptions and details on the curricula.

Computer Science Leading to the Bachelor of Arts Degree

In addition to an EECS major through the College of Engineering, which confers the B.S. degree, the Computer Science Division also offers the CS major through the College of Letters and Science (L&S), which confers the B.A. degree. An essential difference between the two majors is that the EECS program requires a greater number of math and science courses than the CS program, which requires a greater number of non-technical, or breadth, courses. The computer science major under L&S auspices is not accredited by the Computing Accreditation Commission of the Accreditation Board for Engineering and Technology.

For further information about L&S computer science programs and requirements visit the Computer Science Advising Office in 377 Soda Hall. Useful information can also be found at www.eecs.berkeley.edu.

Details about the computer science major offered through the College of Letters and Science also may be found under the course listings for computer science in the *General Catalog.*

Computer Science Minor

A minor in computer science is available to all undergraduate students at Berkeley with a declared major, except Computer Science and EECS majors, through the College of Engineering. Applications and more information on the Computer Science minor are available at the Computer Science Advising Office, 377 Soda Hall or eecs.berkeley.edu/csugrad/minor.html

Advanced Degree Programs

The Five-Year Bachelor's/Master's Program in EECS (B.A./M.S. or B.S./M.S.)

The combined Bachelor's/Master's program is designed to take outstanding EECS and CS (L&S) undergraduates immediately into an intensive two-semester program conferring the Master of Science degree. This combined program promotes interdisciplinary focus and is best suited to those who are more "professionally oriented" as opposed to those wishing to pursue a more traditional research-based and discipline-specialized advanced course of study such as a Ph.D. As such, a distinguishing feature of this five-year program is its emphasis upon extended study in interdisciplinary, though allied, technical fields such as physics, biology, and statistics, or in professional disciplines such as business, law, or public policy. The program is aptly entitled, "Educating Leaders for the Emerging Global Economy," and reflects a growing need for those who are technically skilled and who also possess an understanding of the business, legal, and social context of technology development and use.

Conferral of the degree requires either writing a thesis (Plan I) or reporting on a project (Plan II), as is required of our other Master's students.

The EECS Graduate Program

The EECS Graduate Program offers a comprehensive program geared toward research and teaching (Master of Science and Doctor of Philosophy). The Master of Science program requires three to four semesters of study, while the Doctor of Philosophy program is normally completed in five to six years.

Admission into the graduate program is extremely competitive, but, once admitted, students have a wide variety of cluster areas from which to choose an affiliation, and a large number of courses and seminars taught by leaders in their fields from which to design their study programs. Students apply to either the Electrical Engineering Division or to the Computer Science Division, although once they have been admitted to the department, the boundaries between the divisions are fluid. The principal area of interest of the student should determine which division to apply to. Students whose principal interests are in the following areas should apply to Electrical Engineering:

- **Communications and Networking**
- **Control, Intelligent Systems and Robotics**
- **Design of Electronic Systems**
- **Energy**
- **Integrated Circuits**
- **MEMS: Micro/Nano Electro Mechanical Systems**
- **Physical Electronics**
- **Signal Processing**

Students whose principal interests are in the following areas should apply to Computer Science:

- **Artificial Intelligence**
- **Computer Architecture and Engineering**
- **Database Management Systems**
- **Graphics**
- **Human-Computer Interaction**
- **Operating Systems and Networking**
- **Programming Systems**
- **Scientific Computing**
- **Security**
- **Theory of Computation**

Students with an interest in Biosystems can apply to either division.

See the department website for more information on graduate study and specializations.

With the exception of those in the Five-Year Bachelor's/Master's Program, most who enter the graduate program do so with the expectation of pursuing their doctorates. The department does, however, accept "M.S. only" students and offers two types of degrees, discussed below.

Master of Science (M.S.)

The Department awards two types of Master of Science degrees:

• *Engineering — EECS:* For EE students with a B.S. degree from an accredited engineering program, or for those who have the equivalent of a B.S. degree as determined by the department.

• *Computer Science:* For CS students with a B.S. in computer science, or an equivalent as determined by the department.

Students may choose to pursue Plan I, which requires writing a thesis, or they may pursue Plan II, which requires a report on a project.

Doctor of Philosophy (Ph.D.)

The department offers two types of Ph.D. degrees, awarded to students under the same conditions as the corresponding M.S. degrees, above:

• *Engineering — EECS*

• *Computer Science*

The principal requirements for the Ph.D. are: (1) coursework from a major subject area and two minor subject areas; (2) the departmental preliminary requirement, consisting of an oral exam and breadth courses, which differ for EE and CS; (3) the qualifying exam; and (4) the dissertation. There is no foreign language requirement. For further information on establishing major and minor subject areas, division-specific requirements for prelims and breadth requirements, qualifying exam, and the dissertation, please refer to the Graduate Handbook prepared by the Student Affairs Office at eecs.berkeley.edu/Gradnotes.

Designated Emphasis (DE): In keeping with the departmental priority given to cross-disciplinary applications of engineering and computer science, graduates may also choose to add a designated emphasis to their program. A designated emphasis is a specialization offered by existing Ph.D. programs that provides multi-disciplinary training and research opportunities outside of EECS proper, but in areas that share overlapping interests and goals. At present, six such designated emphases are available to our doctoral students:

- **Computational Science and Engineering**
- **Communication, Computation and Statistics**
- **Computational and Genomic Biology**
- **Energy Science and Technology**
- **Nanoscale Science and Engineering**
- **New Media**

Students who pursue a DE receive recognition of their specialization on their transcripts and diplomas and are well positioned to compete for preferred jobs in academia and industry.

The Management of Technology (MOT) Certificate Program: This program is a joint effort between the College of Engineering, Haas School of Business, and the School of Information (SI) at Berkeley. See the Management of Technology section for more information.

Facilities

The department is supported by state of the art laboratory facilities for computing, robotics, embedded systems, microfabrication, electronic devices, signal processing, networking, communications systems, and nanotechnology. Most of the advanced research is carried out in CITRIS, Cory and Soda Halls, but some advanced study and research are performed in the Space Sciences Laboratory, Radio Astronomy Laboratory, Lawrence National Laboratories (Berkeley and Livermore), and the Center for Pure and Applied Mathematics. More information on facilities can be found by exploring the Centers and Labs section of the department website.

Undergraduate Program in Electrical Engineering and Computer Sciences		116-123*
Freshman Year	*Fall*	*Spring*
CS 61A – Structures and Interpretation of Computer Programs	4	-
CS 61B or 61BL – Data Structures	-	4
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Science Elective (see approved list in EECS Undergraduate Notes)	4	-
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
Total	**16**	**16**
Sophomore Year		
CS 61C or 61CL – Machine Structures	-	4
EE 20N – Structure and Interpretation of Systems Signals	4	-
EE 40 – Introduction to Microelectronic Circuits	-	4
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
First and Second Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**15-16**	**15-16**
Junior Year		
CS 70 – Discrete Mathematics and Probability Theory,	4	-
Electives (EECS upper division)	8	12
Third Additional Humanities/Social Sciences Course[1]	-	3-4
Ethics/Social Implications of Technology[3]	1-4	-
Total	**13-16**	**15-16**
Senior Year		
Technical Electives[2]	6	-
Fourth Additional Humanities/Social Sciences Course[1]	3-4	-
Free Electives[4]	3	14
Total	**12-13**	**14**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Students must take a total of 45 units of engineering courses, including at least 20 units of upper division EECS courses. The 45 units of engineering courses cannot include: any course taken on a P/NP basis; courses numbered 24, 39, 84; BioE 100; CS 194, 195, C195; E 100, C111, 140, 191, 193, 196; EE 194; IEOR 172, 190 series.

[3] Students must complete one course about engineering ethics or the social implications of technology. This may be fulfilled by completing one of the following courses: CS 195, CS H195, ERG 100 or ERG C100, ISF 60 ISF 100D.
CS H195, ERG 100 or C100, ISF 60 and ISF 100D fulfill both a Humanities/Social Science requirement and the EECS ethics/social implications of technology requirement.

[4] Free electives can be any technical or non-technical course

***A minimum of 120 units is required for graduation.**

Detailed curriculum for each of the Electrical Engineering and Computer Sciences Options, refer to the EECS Undergraduate Notes available at eecs.berkeley.edu/Programs/Notes.

Engineering Science

230 Bechtel Engineering Center #1708
(510) 642-8790
coe.berkeley.edu/engsci
Chair: Tarek Zohdi, Ph.D.

Department Overview

The Engineering Science Program is administered by the Engineering Science Committee. Faculty associated with the major are listed at coe.berkeley.edu/engineering-science-committee.

The Engineering Science Program is multidepartmental and interdisciplinary. This undergraduate program encompasses a variety of closely-related areas of the physical and biological sciences, mathematics, and engineering. It is intended to provide a means whereby students, while acquiring knowledge of engineering methods, can pursue their interests in areas of natural science. The options offered within the curriculum prepare students for advanced study in engineering, science, bioengineering, or mathematics.

There are four fully structured majors in the curriculum: Computational Engineering Science, Engineering Mathematics and Statistics, Engineering Physics and Environmental Engineering Science.

Computational Engineering Science. This interdisciplinary program recognizes the growing importance of computation as a methodology for attacking complex scientific and engineering problems. Combined with mathematical modeling and experimental observations, scientific computation enables engineers and scientists to solve problems that are otherwise intractable. The computational engineering science program provides a solid foundation in mathematics, the sciences, and engineering and fosters skills required for modeling, simulating, and solving complex problems. The emphasis is on the computation of science rather than the science of computation (i.e., CES is *not* computer science). Students have the opportunity to select courses from a wide variety of disciplines. The program provides a sound basis for graduate studies in engineering and the applied sciences. Additionally, it nurtures skills that are needed in large-scale technological modeling and simulations relevant to research in industry and national laboratories.

Engineering Mathematics and Statistics. This interdisciplinary program offers students an opportunity to study pure and applied mathematics as essential components of modern engineering. By combining courses from pure mathematics, applied mathematics, statistics, the physical sciences, and engineering, a student may individualize a program of study in theory or applications, or both. The program provides a broad foundation for graduate studies in theoretical branches of engineering, as well as in mathematics. Alternatively, an appropriate choice of courses can prepare students for a career in specific sectors of industry or business. Also, students may choose to minor in a branch of engineering.

Engineering Physics. This program interweaves classical and modern physics, chemistry, and mathematics with their engineering applications. A great strength of the program is its flexibility. The firm base in physics and mathematics is augmented with a selection of engineering course options that prepare the student to tackle the complex problems faced by society. Because the program emphasizes science and mathematics, students are well-prepared to pursue graduate studies in physics or engineering.

Environmental Engineering Science. This is a multidisciplinary field requiring an integration of physical, chemical, and biological principles with engineering analysis for environmental protection and restoration. The program incorporates courses from many departments on campus to create a discipline that is rigorously based in science and engineering, while addressing a wide variety of environmental issues. Although an environmental engineering option exists within the civil engineering major, the engineering science curriculum provides a more broadlybased foundation in the sciences than is possible in civil engineering. This major prepares the student for a career or graduate study in many environmental areas.

Undergraduate Programs in Engineering Science

The programs in Engineering Science are all interdisciplinary. Students are encouraged to plan their individual programs in consultation with their faculty advisers. Students will be advanced to the upper division in Engineering Science upon satisfactory completion of the lower division requirements.

Computational Engineering Science		**120.5-126.5 Units***
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry	4	-
E 7 – Introduction to Computer Programming for Scientists & Engineers	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
E 39B – Introduction to Computational Engineering Science	-	1.5
Reading and Composition Course from List A[2]	4	-
Reading and Composition Course from List B[2]	-	4
Total	**15**	**17.5**
Sophomore Year		
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Mathematics 55 – Discrete Mathematics, Statistics 134 – Concepts of Probability, Mathematics 110 – Linear Algebra, ***or*** CS 70 – Discrete Mathematics and Probability Theory	3-4	-
Physics 7B – Physics for Scientists and Engineers	4	-
Science Electives[1]	4-5	8-9
First Additional Humanities/Social Sciences Course	-	3-4
Total	**15-17**	
15-17		
Junior Year		
E 177 – Advanced Programming with MATLAB	-	3
E 170 – Introduction to Modeling and Simulation	4	-
Mathematics 128A – Numerical Analysis	4	-
Mathematics 128B – Numerical Analysis	-	4
CES Cluster Course 1[3]	4	-
CES Cluster Course 2[3]	-	3
Core Course 1[4]	4	-
Core Course 2[4]	-	3
Second Additional Humanities/Social Sciences Course[2]	-	3-4
Total	**16**	**16-17**
Senior Year		
E 180A – Computational Engineering Science Modeling and Simulation	-	4
CES Cluster Course 3[3]	3	-
CES Cluster Course 4[3]	-	4
Computational Project Course[5]	4	-
Core Course 3[4]	4	-
Third and Fourth Additional Humanities/Social Sciences Courses	3-4	4
Total	**14-15**	**12**

Because of the interdisciplinary nature of this major, electives may be approved throughout the year. For the most updated list of approved courses, see coe.berkeley.edu/engineering-science/approved-courses.

[1] Three courses from the following list of approved science electives: Biology 1A and 1AL, 1B; Chemistry 1B, 3A and 3AL (cannot receive credit for Chemistry 3A after taking Chemistry 1B), 3B and 3BL; E 45; Physics 7C

[2] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[3] See the example clusters for this major. In collaboration with their advisers, students may choose four courses that form a coherent focus for their studies. At least three courses must be upper division.

[4] A total of three courses from the following fifteen groups. Only one course per group is allowed. Many courses on this list have prerequisites. Students should plan carefully to be sure that prerequisites are met.

Applied Math: E 117
Bioengineering: BioE 121, 131, 143
Electrical Engineering: EE 40, 100
Electromagnetics: EE 117, Physics 110A
Engineering Economics: E 120
Engineering Ethics: NE 175
Fluid Mechanics: ME 106, Chem E 150A, CE 100
Operations Research: IEOR 160, 165
Properties of Materials: E 45; MSE 102, 111
Nuclear Engineering: NE 101
Quantum Mechanics: Physics 137A
Solid State Electronics: EE 130, Physics 141A
Statics/Dynamics: CE C30/ME C85, Physics 105
Systems, Feedback and Control: EE 120, ME 132
Thermodynamics: Chem E 141, E 115, ME 40, C105B

[5] One course from the approved list of computational project courses:

BioE 143 – Computational Methods in Biology
E 128 – Advanced Engineering Design Graphics
IEOR 131 – Discrete Event Simulation
IEOR 162 – Linear Programming
ME 128 – Computer-Aided Mechanical Design
ME 132 – Design Systems and Feedback
ME 135 – Design of Microprocessor-Based Mechanical Systems
ME 145 – Computer-Aided Thermal Design
ME 180 – Engineering Analysis Using the Finite Element Method
NE 155 – Introduction to Numerical Simulations in Radiation Transport
MSE 215 – Computational Materials Science (taking MSE 215 requires a minimum 3.0 upper division technical GPA and College approval.)

Note: Cluster and core requirement courses must be preapproved by the faculty adviser.

***A minimum of 120 units is required for graduation.**

Computational Engineering Science Clusters

Computational Engineering Science (CES) clusters are intended to provide depth in a cohesive multidisciplinary area. In the junior/senior year, students first select an approved CES cluster from the list below or petition to construct a new CES cluster. Then they choose four courses from the selected CES cluster. Where a core course overlaps with a CES cluster course, students may apply the course to either – but not both – areas.

The following list of clusters is intended to be a representative, evolving set, with additions and modifications resulting from both student petitions and new courses.

Please consult the *General Catalog* for prerequisites.

Bionuclear Engineering:
EE C145B; NE 101, 107, 162, 167

Computational Materials Science:
E 45; MSE 102, 103, 111 (or Physics 141A), 112, 113, 117 (or Physics 141B), 118, 120, 121, 122, 123, 125; NE 120

Environmental Transport:
CE 108, 116, 173; Chem E 150A, 150B, 171; NE 124

Mass and Energy Transport:
Chem E 150A, 150B, 157, 171; ME 106, 107A, 107B, 165, 185

Mechanics:
CE C30, 130N, 131; Integrative Biology 135;
ME C85, 104, 106, 132, 133, 134, 165, 170, 175, 176, 185; Physics 105

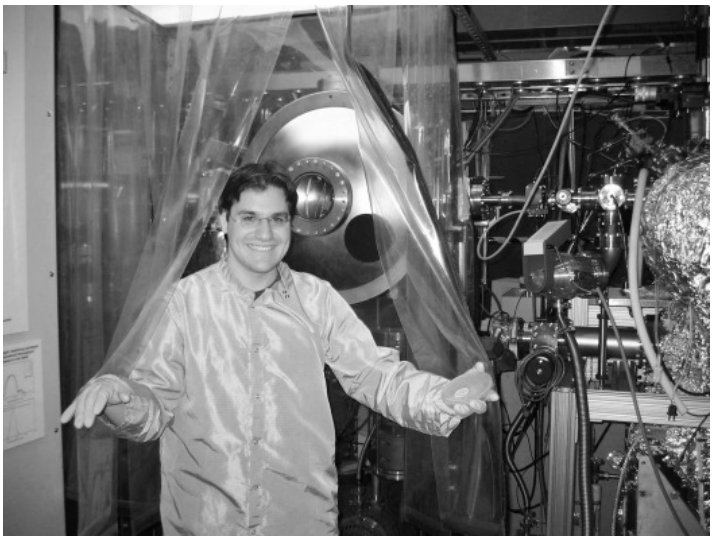
Optimization:
CS 170, 172, 174, 188; IEOR 131, 160, 161, 162, 166

Optoelectronics, Electromagnetics, and Plasmas:
EE 117, 118, 119, 120, 121; MSE 111; NE 180; Physics 142; Statistics 134

Radiation Transport:
NE 101, 124, 130, 150, 155, 162, 170B

Thermodynamics and Combustion:
Chem E 141; E 115; ME 40, 109, 140, 151; Physics 112

Other Clusters:
Additional clusters must be preapproved by the faculty adviser and department by petition.



Engineering Mathematics and Statistics	119-126 Units*	
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A, Physics for Scientists and Engineers	-	4
First Computer Science course[1]	-	3-4
Lower Division Technical Electives (1 course)[2]	-	4
Reading and Composition Course from List A[3]	4	-
First Additional Humanities/Social Sciences Course[3]	3-4	-
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	-
Total	**15-16**	**15-16**
Sophomore Year		
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
Second Computer Science course[1]	3-4	-
Lower Division Technical Electives (1 course)[2]	-	3
Reading and Composition Course from List B[3]	4	-
Second Additional Humanities/Social Sciences Course[3]	-	3-4
Total	**15-16**	**14-15**
Junior Year		
Mathematics 110 – Linear Algebra	3	-
Mathematics 128A – Numerical Analysis	-	4
Mathematics 104 – Introductory and Intermediate Analysis	4	-
Mathematics 105 – Integration Mathematics 185 – Introduction to the Theory of Functions of a Complex Variable	-	4
Statistics 101 – Introduction to the Theory of Probability Statistics 134 – Concepts of Probability	3-4	-
Upper Division Technical Electives[4]	5	4
Third Additional Humanities/Social Sciences Course[3]	-	3-4
Total	**15-16**	**15-16**
Senior Year		
Upper Division Technical Electives[4]	15	12
Fourth Additional Humanities/Social Sciences Course[3]	-	3-4
Total	**15**	**15-16**

Because of the interdisciplinary nature of this major, electives may be approved throughout the year. For the most updated list of approved courses, see coe.berkeley.edu/engineering-science/approved-courses.

[1] Two computer science courses from the following: E 7, 177; CS 61A, 61B or as approved by adviser. Students who opt to take E 177 should check prerequisites before enrollment.

[2] Six units of lower division technical electives selected in consultation with a faculty adviser. Courses approved at the time of printing include: CS 61C; CE C30/ME C85; E 10, 28, 45; Mathematics 55 (transfer students may substitute upper division courses with approval of adviser)

[3] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[4] Electives must include: (a) 16 units of upper division courses in engineering; (b) Three additional upper division courses in mathematics or statistics from among: Mathematics 105, 113, 118, 123, 125A, 126, 128B, 130, 135, 140, 142, 170, 185, 187, 189; Statistics 135, 141, 150, 151A-151B, 152, 157; (c) A coherent series of electives selected in consultation with an adviser to provide depth in an area of engineering with high mathematical content. Lower division courses may be used as long as the student's program has a total of 40 units of approved upper division technical subjects (mathematics, statistics, science, and engineering). Elective series examples include: Computer Science/Computation (e.g. CS 61A, 61B, 61C; Mathematics 55, 113, 115, 128B; IEOR 131, 162; CS 164, 170, 172, and 174); Dynamics, Differential Equations, and Physics (e.g. ME 104 or Physics 105; E115 or Chem E 141; Mathematics 123, 126, 128B; Physics 110A-110B, 112, 137A-137B, 138, 142; ME 106, 165, 170, 175, and 185); Communications and Control Systems (e.g. EE 40, 120; CS 61A, 61B, 61C; ME 134, 135); Operations Research (e.g. E 7; Mathematics C103/Economics C103; Mathematics 55, 113; Statistics 134, 135, 150; E 120; IEOR 131, 160, 161, 162).

Note: Technical electives cannot include: any course that is only offered on a P/NP basis; courses numbered 24, 39, 84; BioE 100; CS 194, 195, C195; E 100, C111, 191, 193, 196; EE 194; IEOR 190 series.

IEOR 172 is an alternative course for Statistics 134. Students may not receive credit for both Statistics 134 and IEOR 172. IEOR 172 cannot be used to fulfill engineering elective units. It can only be used to fulfill statistics electives units course.

***A minimum of 120 units is required for graduation.**

Engineering Physics		118-124 Units*
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry	4	-
Chemistry 1B – General Chemistry	-	4
E 7 – Introduction to Applied Computing, CS 61A – Structure and Interpretation of Computer Programs, ***or*** CS 61B – Data Structures	4	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	-
Total	**16-17**	**16**
Sophomore Year		
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
Technical Electives[2]	4	4
First and Second Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**15-16**	**15-16**
Junior Year		
E 115 – Engineering Thermodynamics ***or*** Physics 112 – Introduction to Statistical and Thermal Physics	-	3-4
Mathematics 104 – Introduction to Analysis and Mathematics 185 –Introduction to Complex Analysis, ***or*** Mathematics 121A and 121B – Mathematical Tools for the Physical Sciences	4	4
ME 104 – Engineering Mechanics ***or*** Physics 105 – Analytic Mechanics	3-4	-
Physics 137A – Quantum Mechanics	4	-
Physics 137B – Quantum Mechanics	-	4
Technical Electives[2]	-	3-4
Third Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**14-16**	**14-16**
Senior Year		
EE 143 – Microfabrication Technology, ***or*** NE 104 – Nuclear Instrumentation Lab, ***or*** Physics 111A – Modern Physics and Advanced Electrical Lab[3]	3-4	-
ME 185 – Introduction to Continuum Mechanics ***or*** ME 106 – Fluid Mechanics	-	3
Physics 110A and 110B – Electromagnetism ***or*** EE 117[4] – Electromagnetic Fields and Waves and either EE 119 – Introduction to Optical Engineering or BioE 164 – Optics and Microscopy	4	3-4
MSE 111 – Electric and Magnetic Properties of Materials ***or*** Physics 141A – Solid State Physics	3-4	-
Technical Electives[2]	4-5	5-6
Fourth Additional Humanities/Social Sciences Course[1]	-	3-4
Total	**14-17**	**14-17**

Because of the interdisciplinary nature of this major, electives may be approved throughout the year. For the most updated list of approved courses, see coe.berkeley.edu/engineering-science/approved-courses.

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Technical electives must include: (a) Two courses from the following lower division technical electives: Astronomy 7A, 7B; Biology 1A, 1B; CE C30/ME C85; Chemistry 3A; E 10, 45; EE 40 (or 100); (b) 16 units of upper division courses in engineering; (c) A minimum of 14 units of upper division physics; (d) At least 40 units of approved upper division technical subjects (mathematics, statistics, science, and engineering).

[3] If chosen, Physics 111A must be taken for at least 3 units.

[4] Students opting to take EE 117 must take either EE 119 or BioE 164. Students opting to take the Physics 110A must take 110B.

***A minimum of 120 units is required for graduation.**

Environmental Engineering Science	117-130 Units*	
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Computer Programming	-	4
First Science Elective: E 10, Biology 1A and AL, Chemistry 1B or 4B, 3A, 3A, Physics 7C, ***or*** Earth and Planetary Science 50[5]	-	3-5
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Additional Humanities/Social Sciences Course[1]	3-4	-
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	-
Total	**15-17**	**15-17**
Sophomore Year		
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Biology 1B – General Biology	4	-
Second and Third Science Electives: see list in Freshman year[5]	4-5	4-5
CE C30/ME C85 – Introduction to Solid Mechanics	-	3
Second Additional Humanities/Social Sciences Course[1]	-	3-4
Total	**16-17**	**14-16**
Junior Year		
CE 111 – Environmental Engineering	-	3
Advanced Mathematics: Math 121A and 121B; Math 110 and 128A; Statistics 134 and 135; ***or*** E 117 and 177	3-4	3-5
Environmental Fluid Mechanics: CE 101, 103, 173; Earth and Planetary Science 105, C129/ Environmental Science Policy and Management C129, ***or*** 181	-	3
Fluid Mechanics: CE 100, Chem E 150A, ***or*** ME 106	3	-
Mechanics: CE 130N ***or*** ME 104	3	-
Thermodynamics: Chem E 141, E 115, ***or*** ME 105B	3	-
Cluster course[2]	-	3
Third and Fourth Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**15-17**	**15-18**
Senior Year		
Advanced Science Sequence[3]	4	4
Cluster Courses[2]	6	3
Fourth Additional Humanities/Social Sciences Course[1]	-	3-4
Free Electives	3	4
Total	**13**	**14-15**

Because of the interdisciplinary nature of this major, electives may be approved throughout the year. For the most updated list of approved courses, see coe.berkeley.edu/engineering-science/approved-courses.

Advanced Science Course Sequences

Choose one of the sequences of eight to 10 units:

(1) Chemistry 112A, 112B, Organic Chemistry (for students who did not take Chemistry 3A, 3B)

(2) Chemistry 120A, 120B, 125

(3) *Nine units from:*
Earth and Planetary Science 101, 105, 108, 116, 117, 124, 146

(4) Nine units from: Earth and Planetary Science 180, 181, 182, Geography 142

(5) *Nine units from:*
Environmental Science Policy and Management 102A, 103, 111, 112, 120, 126, 128, 131

(6) MCB 102, 112/112L

Approved Cluster Courses[2]

Biology:
MCB 112 and 112L, 113, 114, 116, 130, 130L, 148; Plant and Microbial Biology 120, 120L, 150, 150L, 180

Ecology:
Environmental Science Policy and Management 103, 104; Integrative Biology 149, 149L, 151, 151L, 152, 153, 153L, 154, 154L, 162, 166

Energy:
Architecture 140; CE 106, 107, 108; Energy Resources Group 280, ME 109, 140, 146

Geoengineering:
CE 171, 173, 175, 176, C178, C172, 281

Policy Tools:[4]
Economics C103, 104, 118, 126, 141, C142; Political Science 131A; Sociology 105, 106

Process Engineering:
Chem E 140, 142, 150B, 154, 170, 170L, 171

Resources Engineering:
CE 101, 103, 107, 113, 114, 115; Earth and Planetary Science 180; Environmental Science Policy and Management 128; ME 140; NE 124

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] The 12 units of cluster courses are in addition to engineering and science courses used to fulfill other requirements of the program. See approved cluster course list for options.

[3] See Advanced Science Course Sequence. Choose one of the sequences of eight to 10 units.

[4] The following policy courses are recommended for fulfilling the H/SS requirements: Environmental Economics and Policy 161 – Advanced Topics in Environmental and Resources Economics; Environmental Economics and Policy 162 – Economics of Water Resources; Econ 125 – Economics of the Environment; Energy and Resources Group 100 – Energy and Society; Energy and Resources Group 151 – Politics of Energy and Environmental Policy; Public Policy 101 – Introduction to Public Policy Analysis; Public Policy 158 – Risk and Uncertainty in Public Policy; Public Policy 175 – Science and Technology Policy.

[5] All prerequisites must be satisfied before taking any class

***A minimum of 120 units is required for graduation.**

Engineering — Undeclared

230 Bechtel Engineernig Center #1702
(510) 642-7594
coe.berkeley.edu/engineering-undeclared

Program Overview

The engineering-undeclared lower division program is for students who are interested in pursuing an engineering education but are undecided on a particular major within the College.

Students admitted to the program enjoy the benefit of an advising team including a student academic adviser who works exclusively with undeclared students and faculty from each major. Together they help students in the program explore their academic interests, understand and complete requirements, and select a major. The common first year engineering curriculum is supplemented with introductory seminars and courses intended to generate enthusiasm for and develop a better understanding of the different engineering fields.

Students admitted to the program must declare a major by the end of their fourth semester, and if in good academic standing may choose from any of the College of Engineering majors.

Sample Program for Engineering — Undeclared

Freshman Year	*Fall*	*Spring**Chemistry***
1A – General Chemistry	***4***	**-**
Chemistry 4A – General Chemistry and Quantitative Analysis		
E 7, Introduction to Applied Computing[1]	-	4
E 10, Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A, Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[2]	4	-
Reading and Composition Course from List B[2]	-	4
E 92 – Perspectives in Engineering	1	-
Total	**16**	**16**
Sophomore Year		
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B, Physics for Scientists and Engineers	4	-
First Additional Humanities/Social Sciences Course[2]	3-4	-
Electives (Fall)[3]	*see your advisers*	-
Electives (Spring)[3]	-	*see your advisers*
Total	**15-16**	**13-16**

[1] Intended electrical engineering and computer sciences majors should discuss this requirement with their advisers. CS 61A may be a more appropriate choice.

[2] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[3] Students should choose these requirements with their student affairs and faculty advisers based upon their intended major(s).

Industrial Engineering and Operations Research

4141 Etcheverry Hall #1777
(510) 642-5484
ieor.berkeley.edu
Chair: Rhonda Righter, Ph.D.

Department Overview

The Department of Industrial Engineering and Operations Research combines two closely related professions concerned with the efficient operation of complex systems. The industrial engineering profession involves the design, organization, implementation, and economic operation of integrated production and service systems using people, materials, and equipment. Areas of application include not only the basic manufacturing and high technology production processes essential to our economy but also service organizations such as banks, health care facilities, libraries, and government agencies. Operations research emphasizes the basic understanding of the functioning of complex systems of technology and management through the development and analysis of mathematical models for the purpose of predicting system behavior and/or optimizing system performance, under economic and technological constraints. In addition to production and service systems described above, application areas include engineering systems such as transportation, energy production and delivery, construction management, and resource extraction; socio-technological problems such as urban services, environmental planning, waste management, and law enforcement systems; and management areas such as financial and investment analysis, resource allocation, risk analysis, and manpower planning. Both professions require a sound preparation in the mathematical sciences such as probability, statistics, and optimization theory, as well as training in economic principles, human performance and organization, and the use of computers to analyze and/or simulate systems. Elective studies can emphasize a particular area of technology or can be broadly based in either management systems or decision methodology.

Undergraduate Program

The undergraduate program in the Department of Industrial Engineering and Operations Research is designed to prepare students for technical careers in production or service industries; alternatively, it provides a strong foundation for those headed for engineering management positions, as well as those intending to go on to specialized graduate study in operations research, industrial engineering, or business administration. The core of the program includes basic science, mathematics, including probability and statistics, and engineering, followed by courses in optimization and stochastic models. These courses form the methodological foundation for upper division IEOR electives involving the analysis and design of production and service systems, information systems, and human work systems and organization, among others. The senior project enables the student to integrate knowledge acquired in other courses and apply it to the solution of actual problems from local industrial firms and government agencies.

The mission of the Department of Industrial Engineering and Operations Research is to educate students to become highly proficient in:

• the quantitative modeling and analysis of a broad array of systems level decision problems concerned with economic efficiency, productivity, and quality;

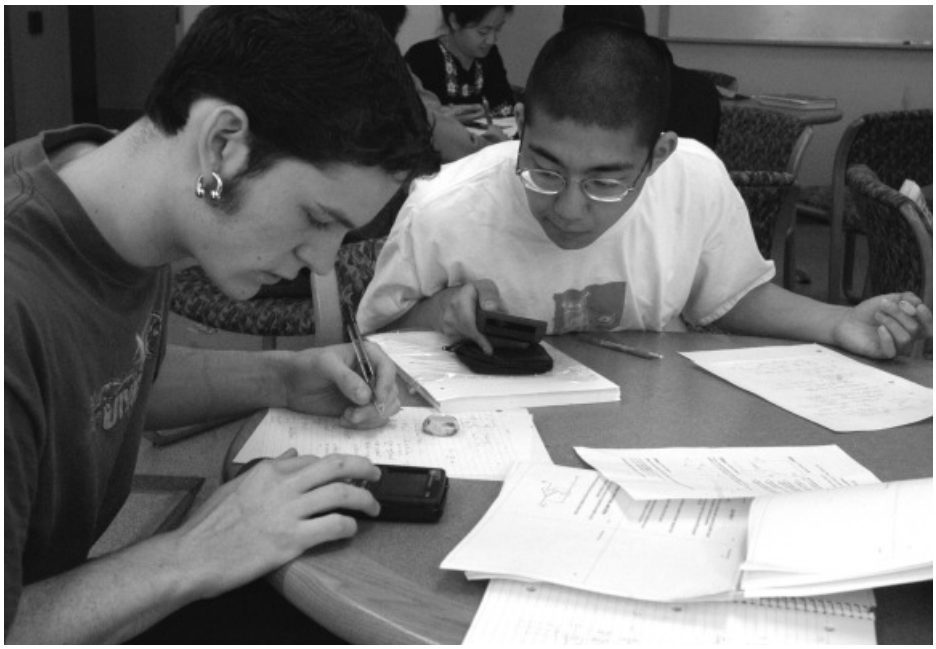
• the development and creative use of analytical and computational methods for solving these problems;

• the collection and analysis of data, and the use of database and decision-support tools;

• the comprehension of modeling and uncertainty; and

• to obtain the broader skills, background, and knowledge necessary to be an effective professional in a rapidly changing global economy.

The undergraduate program is accredited under the guidelines for industrial engineering programs by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: (410) 347-7700.



Berkeley's IEOR Department recognizes the importance of integrating undergraduate education in both its engineering discipline and its fundamental science base. This was accomplished by the foundation, in 2004, of the first full major in the nation within an arts and sciences college wholly run by an engineering department. Our Operations Research and Management Science (ORMS) major is the only such intercollege program in any engineering discipline.

Our ORMS major is designed for students in Berkeley's College of Letters and Sciences. It provides a solid foundation in the quantitative, model building, and problem solving skills of operations research and management science. It also gives students the flexibility to focus on a particular topic of interest to them in which they can apply these skills. More information on our ORMS major can be found at http://www.ieor.berkeley.edu/AcademicPrograms/Ugrad/index.htm

Industrial Engineering and Operations Research Minor

The department offers a minor in industrial engineering and operations research that is open to all students not majoring in IEOR who have completed the necessary prerequisites for the minor requirements. Information is available at the department office.

Graduate Study

Applicants to the graduate programs in Industrial Engineering and Operations Research should have a bachelor's degree in engineering, physical science, mathematics, or other fields that provide sufficient mathematical preparation.

At the master's level, students may emphasize applied courses, preparing them for professional practice or may follow a more theoretical program intended for those who will pursue doctoral studies. In doctoral programs, students investigate additional major topics indepth, as well as study two minor fields. A minor may augment the major in several ways, such as to provide a deeper understanding of the theory underlying portions of the major field, or to introduce an area of potential applications.

The paramount requirement of a doctoral degree is the successful completion of a thesis on a subject within the major field. Research areas may include the investigation of the mathematical foundations of, and computational methods for, optimization or stochastic models, including risk analysis. Research also may be undertaken to develop methodologies for the design, planning, and/or control of systems in a variety of application domains, including manufacturing, distribution, material handling, transportation, power generation, health care, financial services, information services, and governmental services.

Graduate students are expected to become proficient in the use of computers. Students should be able to quickly construct simple computer programs and to use software libraries and applications for such tasks as data analysis, optimization, and large scale system simulation.

The department offers a certificate program in logistics, which is cosponsored by the Department of Civil and Environmental Engineering. The department also participates in the management of the technology certificate program (MOT), which is jointly sponsored by the College of Engineering and Haas School of Business. The certificate programs are designed to provide focus on courses and campus activities related to logistics and the management of technology, respectively. Students enrolled in an M.S. or an M.Eng. program in either department can meet the certificate requirements by a judicious choice of electives without increasing the total number of credit hours toward their master's degree. Students enrolled in other departments are welcome to participate in the programs.

You may obtain further information about graduate programs in this department by exploring our website or contacting the department office.

Facilities

The Department of Industrial Engineering and Operations Research has two computing laboratories. Both use a network of Windows-based personal computers equipped with industry-standard software applications for instruction and research. Printing and scanning services are available. The department also shares an onsite computing facility that is equipped with a cluster of linux computers for high performance application processing. Wireless access is available throughout the building.

Program in Industrial Engineering and Operations Research		117-124 Units*
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Applied Computing	-	4
E 10 – Engineering Design and Analysis[2]	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	-
Total	**15-16**	**16**
Sophomore Year		
E 120 – Engineering Economics	-	3
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Self Pace Programming Course (see note #1)	-	1
Engineering Breadth[3]	3	3
First and Second Additional Humanities/Social Sciences Course[1]	3-4	3-4
Total	**14-15**	**14-15**
Junior Year		
IEOR 131– Computer Simulation of Industrial Engineering Systems	-	3
IEOR 160 – Operations Research I	3	-
IEOR 161 – Operations Research II	-	3
IEOR 162 – Linear Programming	3	-
IEOR 165 – Engineering Statistics, Quality Control and Forecasting	-	3
IEOR 172 – Probability and Risk Analysis for Engineering ***or*** Statistics 134 – Concepts of Probability	3	-
IEOR Electives[4]	3	3
Third and Fourth Additional Humanities/Social Sciences Course[1]	3-4	3-4
Total	**15-16**	**15-16**
Senior Year		
IEOR 180 – Senior Project	-	4
IEOR Electives[4]	9	6
Unrestricted Electives (9 units minimum)	6	3-5
Total	**15**	**13-15**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Transfer students who did not complete an approved E10 equivalent course prior to admission must take an approved course (three units minimum) treating engineering technology, design or analysis. See your student academic adviser in 230 Bechtel Engineering Center for details.

[3] Engineering Breadth: six units must be completed from the following list: BioE 102; CE 11, C30, 60, 70, 155; E 28, 36, 45, 115; EE 40 (or 42 or 100); MSE 111, ME 40, C85, 132.

[4] Students must take a minimum of six courses from the list below:

IEOR 115 – Industrial and Commercial Data Systems
IEOR 130 – Methods of Manufacturing Improvement
IEOR 140 – Industrial Production and Design (the prerequisite is a course in Java programming equivalent to CS 9G.)
IEOR 166 – Decision Analysis
IEOR 150 – Production Systems Analysis
IEOR 151 – Service Operations Design and Analysis
IEOR 153 – Facilities Planning and Design
IEOR 170 – Human Factors for Engineering Design
IEOR 171 – Introduction to Design of Human Work Systems and Organization

Additional requirements/Notes:
(1) A course in Computer Programming must be completed by the end of your sophomore year: CS 9C, 9F, 9G, or any equivalent course work (with evaluation and approved petition) is acceptable. CS 9G is a prerequisite for IEOR 140.

(2) No course can be used to satisfy simultaneously two requirements.

(3) IEOR 172 is an alternative course for Statistics 134. In semesters when both are offered, we recommend you take IEOR 172. Students may not receive credit for both Statistics 134 and IEOR 172. IEOR 172 cannot be used to fulfill any engineering unit or elective requirements. It can only be used as a statistics course.

(4) The IEOR 190 series courses cannot be used to fulfill any engineering requirements (units, courses, technical electives or otherwise).

***A minimum of 120 units is required for graduation.**

Manufacturing Engineering

Program Overview

Manufacturing engineering is an interdisciplinary undergraduate program offered jointly by the Departments of Industrial Engineering and Operations Research and Mechanical Engineering. The emphasis of the program is on how to manufacture products of high quality, including machinery design, plant layout, employee supervision, and economic analysis. The program demands creativity and the ability to solve problems and communicate effectively.

Course topics include computer-aided manufacturing, robotics and automated machining, production systems analysis, properties of materials, systems design and synthesis, reliability, optimization, quality management, and manufacturing processes. These fundamentals are applied to a variety of manufacturing industries, including integrated circuit, automobile, steel, and electronics.

[1] Electives must include the following: The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Choose two courses from each of the following two groups:

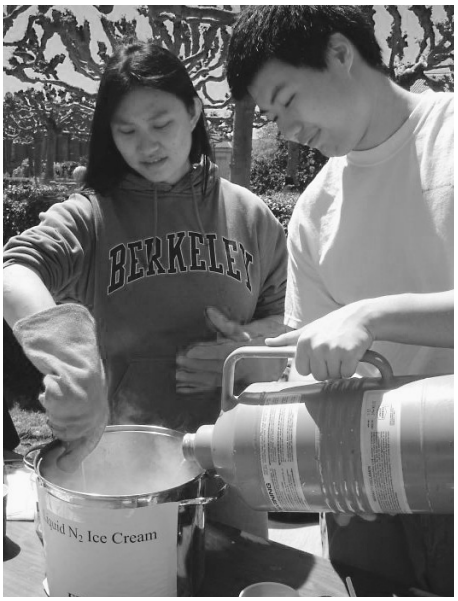
Group 1

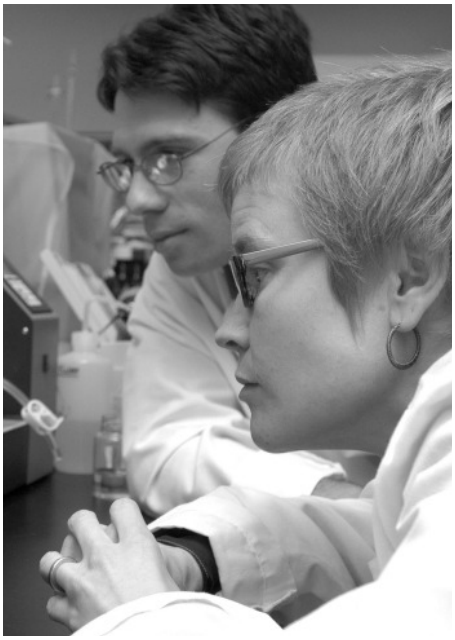
ME 102A – Experimentation and Measurement
ME 106 – Fluid Mechanics
ME 109 – Heat Transfer
ME 110– Introduction to Product Development
ME 128 – Computer-Aided Mechanical Design
ME 130 – Design of Planar Machinery
ME 133 – Mechanical Vibrations
ME 134 – Automatic Control Systems
ME 135 – Design of Microprocessor-Based Mechanical Systems
ME 132 – Dynamic Systems and Feedback

Group 2:

IEOR 115 – Industrial and Commercial Data Systems
IEOR 131 – Computer Simulation of Industrial Engineering Systems
IEOR 161 – Operations Research
IEOR 162 – Linear Programming
IEOR 166 – Decision Analysis
IEOR 170 – Human Factors for Engineering
IEOR 171 – Introduction to Design & Supply Chain Management

Undergraduate Program in Manufacturing Engineering		123-131 Units
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Applied Computing	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
Total	**15**	**16**
Sophomore Year		
E 28 – Graphic Communication in Engineering	3	-
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
ME 40 – Thermodynamics	-	3
ME C85 – Introduction to Solid Mechanics	-	3
Physics 7B – Physics for Scientists and Engineers	4	-
Three Additional Humanities/Social Sciences Courses[1]	3-4	6-8
Total	**14-15**	**16-18**
Junior Year		
E 120 – Principles of Engineering Economy	3	-
EE 100 – Electronic Techniques for Engineering	4	-
IEOR 130 – Modeling and Simulation of Dynamic Systems	-	3
IEOR 140 – Introduction to Industrial Production Methods	-	4
IEOR 160 – Operations Research I ***or*** IEOR 162 – Linear Programming	-	3
IEOR 172 – Probability and Risk Analysis for Engineers ***or*** Statistics 134 – Concepts of Probability	3	-
ME 101 – Manufacturing Systems	3	-
ME 104 – Engineering Mechanics II (Dynamics)	-	3
ME 108 – Mechanical Behavior of Engineering Materials	-	4
Total	**14**	**17**
Senior Year		
IEOR 150 – Production Systems Analysis	3	-
IEOR 153 – Facilities Planning and Design	3	-
IEOR 165 – Forecasting, Quality Control, and Quality Assurance	-	3
ME 102B, Mechanical Engineering Design ***or*** IEOR 180, Senior Project	3-4	4
ME 122 – Processing of Materials in Manufacturing	-	3
Technical Electives[2]	3-6	6
Fourth Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**15-20**	**16**





Materials Science and Engineering

210 Hearst Memorial Mining Building #1760
(510) 642-3801
mse.berkeley.edu
Chair: Robert O. Ritchie, Sc.D.

Department Overview

The Department of Materials Science and Engineering administers undergraduate and graduate programs in materials science and engineering. In addition, undergraduate students may be admitted to one of several joint major programs.

Materials science and engineering encompasses all natural and manmade materials — their extraction, synthesis, processing, properties, characterization, and development for technological uses. Advanced engineering activities that depend upon optimized materials include the medical device and healthcare industries, electronics and photonics, transportation, advanced batteries and fuel cells, and the emerging field of nanotechnology.

Students in materials science and engineering apply a basic foundation of mathematics, chemistry, physics, and engineering to fields of specialization that include: biomaterials; electronic, magnetic, and optical materials; materials for energy technologies; structural materials; chemical and electrochemical materials science and engineering; and computational materials science and engineering. Nanoscale science and engineering plays a important role in all of these specializations.

Biomaterials

Traditionally, biomaterials encompass synthetic alternatives to the native materials found in the human body. A central limitation in the performance of traditional materials used in the medical device, biotechnological, and pharmaceutical industries is that they lack the ability to integrate with biological systems through either a molecular or cellular pathway, which has relegated biomaterials to a passive role dictated by the constituents of a particular environment, leading to unfavorable outcomes and device failure. The design and synthesis of materials that circumvent their passive behavior in complex mammalian cells is the focus of the work conducted within the MSE department at UC Berkeley.

Chemical and Electrochemical Materials Science and Engineering

This area comprises both the chemical and electrochemical processing of materials and the chemical and electrochemical behavior of materials. The former includes the scientific and engineering principles utilized in mineral processing, smelting, leaching and refining materials, along with numerous etching and deposition techniques. The latter includes the environmental degradation of materials, the compatibility of materials with specific environments, and the fundamental science and engineering development of materials used in advanced energy storage devices.

Computational Materials Science and Engineering

Computational methods are becoming increasingly useful in all facets of materials science and engineering. Such methods range from the theoretical prediction of the electronic and structural properties of materials to modeling fluid flow in advanced batteries or the chemical kinetics and equilibria in a materials-processing operation.

Electronic, Magnetic and Optical Materials

This group of materials is defined by its functionality. Semiconductors, metals, and ceramics are used today to form highly complex systems, such as integrated electronic circuits, optoelectronic devices, and magnetic and optical mass storage media. In intimate contact, these various materials, with precisely controlled properties, perform numerous functions, including the acquisition, processing, transmission, storage, and display of information. Materials research in this area combines the fundamental principles of solid state physics and chemistry with electrical engineering, chemical engineering, and materials science and engineering.

Materials for Energy Technologies

Materials play a crucial enabling role in the energy technologies. All facets of energy harvesting, conversion, storage, delivery, and conservation are included in this topic. Specific examples include photovoltaics, nuclear materials, thermoelectrics, fuel cells, mechanical transducers, batteries, low-loss conductors, low-density structural materials for weight savings, and integrated materials systems for automated control of energy utilization. Technical courses relevant to this field of study are selected from undergraduate offerings in Materials Science and Engineering, Chemical Engineering, Nuclear Engineering, and Mechanical Engineering, and one course on energy policy may also be included.

Nanomaterials

The science of materials at the nanoscale provides a rich scholarly focus at the confluence of basic science (physics, chemistry, biology, and mathematics) and the engineering disciplines. This interdisciplinary focus will provide undergraduates with a comprehensive view of the key materials science issues in nanoscience and nanotechnology. Several courses on nanoscale processing, characterization, and computational approaches to understand nanomaterials are being offered under this concentration.

Structural Materials

This area focuses on the relationships between the chemical and physical structure of materials and their properties and performance. Regardless of the material class — metallic, ceramic, polymeric, or composite — an understanding of structure-property relationships provides a scientific basis for developing engineering materials for advanced applications. Fundamental and applied research in this field respond to an ever-increasing demand for improved or better-characterized materials.

Undergraduate Program

Undergraduate students in the MSE curriculum pursue a program that applies the principles of mathematics, physics, chemistry, and engineering to materials systems. The program emphasizes the relationships among these underlying principles and the structure, properties, processing, and performance of materials. Students learn to apply and integrate their understanding of materials structure, properties, processing, and performance to materials selection and design problems. The program introduces relevant experimental and computational methods and includes technical electives. Courses selected to satisfy these requirement are chosen to emphasize biomaterials, electronic materials, materials physics and chemistry, structural materials, energy, technology, nanomaterials, or follow a general emphasis.

Joint Major Programs

The department offers five joint major programs that combine study in materials science and engineering with bioengineering, electrical engineering and computer sciences, mechanical engineering, nuclear engineering, or chemical engineering.

See the “Joint Majors” section of this announcement for descriptions and detailed curricula for each joint major.

Materials Science and Engineering Minor

The department offers a minor in materials science and engineering that is open to all students not majoring in MSE who have completed the necessary prerequisites for the minor requirements. Information is available at the department office.

Graduate Study

Qualified holders of the bachelor’s degree in fields such as materials science and engineering, ceramic engineering, metallurgy, physics, chemistry, and various fields of engineering can all successfully undertake graduate study in materials science. A combination of course work and research normally leads to the M.S., M.Eng., and Ph.D. degrees, qualifying the graduate for a wide range of positions in industry, governmental organizations, or universities that entail research or engineering in the production, development, and use of materials. The course work includes a core program in materials science and engineering, along with additional courses that provide breadth. Topics for graduate research include studies in biomaterials; electronic, magnetic and optical materials; structural materials; chemical and electrochemical materials science and engineering; and computational materials science and engineering. There is also a designated emphasis in nanoscale science and engineering (see the “NSE” section of this announcement).

Facilities

Instruction and research in the Department of Materials Science and Engineering are supported by excellent and extensive facilities located on the Berkeley campus and within the Lawrence Berkeley National Laboratory (LBNL). Campus facilities for materials synthesis and characterization are found in Hearst Memorial Mining Building, Berkeley’s Microfabrication Laboratory, and the Integrated Materials Laboratory. At Lawrence Berkeley National Laboratory, several unique facilities used by materials scientists and engineers are found in the Materials Sciences Division (MSD), at the National Center for Electron Microscopy (NCEM), the Advanced Light Source (ALS), and the National Energy Research Scientific Computing Center (NERSC). Further details on these and other facilities for teaching and research can be found by visiting the department’s website.

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Technical electives must include at least 21 units of upper division courses and may be chosen from a single area of technical emphasis: Biomaterials, Electronic Materials; Energy Technology; Materials Physics and Chemistry; Nanomaterials; Structural Materials; or a general emphasis that includes an integrated course sequence in another engineering field, physics, chemistry, or mathematics. The 21 units of upperdivision courses cannot include: any course taken on a P/NP basis; BioE 100; CS 194, 195, C195; E 100, C111, 140, 191, 193, 196; EE 194; IEOR 190 series.

Undergraduate Program in Materials Science and Engineering — 122-128 Units

Core Program

Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Applied Computing	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	<1>
Total	**15-16**	**15-16**
Sophomore Year		
Chemistry 1B – General Chemistry Chemistry 4B – General Chemistry and Quantitative Analysis	-	4
E 45 – Properties of Materials	-	3
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
ME C85 – Introduction to Solid Mechanics	3	-
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
First and Second Additional Humanities/Social Sciences Courses[1]	6-8	-
Total	**17-19**	**15**
Junior Year		
E 115 – Engineering Thermodynamics	4	-
E 117 – Methods of Engineering Analysis	3	-
MSE 102 – Bonding, Crystallography and Crystal Defects	3	-
MSE 103 – Phase Transformations and Kinetics	-	3
MSE 104 – Characterization of Materials	-	4
MSE 111 – Properties of Electronic Materials	-	4
Third and Fourth Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Technical Electives[2]	3	3
Total	**16-17**	**17-18**
Senior Year		
MSE 112 – Corrosion	-	3
MSE 113 – Mechanical Behavior of Materials	3	-
MSE 130 – Experimental Materials Science	3	-
MSE 151 – Polymeric Materials	-	3
Technical Electives[2]	9	6
Total	**15**	**12**

Biomaterials Emphasis
Core Program plus the following:

Junior Year	*Fall*	*Spring*
Technical electives approved for emphasis in Biomaterials[1]	3	-
MSE C118 – Biological Performance of Materials	-	3
Total	**3**	**3**
Senior Year		
Courses approved for emphasis in Biomaterials[1]	6	9
Total	**6**	**9**

Electronic Materials Emphasis
Core Program plus the following:

Junior Year	*Fall*	*Spring*
Courses approved for emphasis in Electronic Materials[2]	3	3
Total	**3**	**3**
Senior Year		
MSE 117 – Properties of Dielectric and Magnetic Materials	-	3
MSE 123 – Semiconductor Processing	3	-
MSE 125 – Thin-Film Materials Science	-	3
Courses approved for emphasis in Electronic Materials[2]	3	3
Total	**6**	**9**

Materials Physics and Chemistry Emphasis
Core Program plus the following:

Junior Year	*Fall*	*Spring*
Courses approved for emphasis in Materials Physics and Chemistry[3]	3	3
Total	**3**	**3**
Senior Year		
Courses approved for emphasis in Materials Physics and Chemistry[3]	6	9
Total	**6**	**9**

Structural Materials Emphasis
Core Program plus the following:

Junior Year		
MSE 122 – Ceramic Processing	3	-
Courses approved for emphasis in Structural Materials[4]	-	3
Total	**3**	**3**
Senior Year		
CE 131 – Advanced Mechanics of Materials	3	-
ME 127 – Composite Materials: Analysis, Design, Manufacture	3	-
Courses approved for emphasis in Structural Materials[4]	-	9
Total	**6**	**9**

[1] Technical electives in the Biomaterials emphasis must include one MSE 120 series course and the remaining courses from the following approved list. (Consult the *General Catalog* for prerequisites.) Substitution of courses not on this list requires adviser approval.

Chem E 170A-170B – Biochemical Engineering
Chemistry 112A-112B – Organic Chemistry
Chemistry C130/Molecular and Cell Biology C100A – Biophysical Chemistry: Physical Principles and the Molecules of Life
Chemistry 130B – Biophysical Chemistry
ME C176 – Orthopaedic Biomechanics
Molecular and Cell Biology 100B – Biophysical Chemistry: Physical Principles and the Molecules of Life
Molecular and Cell Biology 102 – Survey of the Principles of Biochemistry and Molecular Biology
Molecular and Cell Biology 110 – Molecular Biology: Macromolecular Synthesis and Cellular Function

[2] Technical electives in the Electronic Materials emphasis must be taken from the following approved list. (Consult the *General Catalog* for prerequisites.) Substitution of courses not listed below requires adviser approval.

EE 100 – Electronic Techniques for Engineering, (or EE 40 – Introduction to Microelectronic Circuits if taken as a sophomore)
EE 130 – Integrated-Circuit Devices
MSE 120 series course (other than 123 and 125)
Physics 137A-137B – Quantum Mechanics
Physics 141A-141B – Solid-State Physics

[3] Elective in the Materials Physics and Chemistry Emphasis must include one MSE 120 series course and the remaining units from the following approved list. (Consult *General Catalog* for prerequisites.) Substitution of courses not listed below requires adviser approval.

Chemistry 104A and/or 104B – Advanced Inorganic Chemistry
Chemistry 105 – Instrumental Methods in Analytical Chemistry
Chemistry 120A and/or 120B – Physical Chemistry
Chemistry 125 – Physical Chemistry Laboratory
Chemistry 112A and/or 112B and/or 112H – Organic Chemistry
MSE 117 – Dielectric, Magnetic and Optical Properties of Materials
Physics 110A and/or 110B – Electromagnetism and Optics
Physics 112 – Introduction to Statistical and Thermal Physics
Physics 137A-137B – Quantum Mechanics
Physics 141A-141B – Solid-State Physics

[4] Electives in the Structural Materials emphasis must include one MSE 120 series course and the remaining units from the following approved list. (Consult *General Catalog* for prerequisites.) Substitution of courses not on this list requires adviser approval.

CE 120 – Structural Engineering
CE 122 – Design of Steel Structures
CE 140 – Failure Mechanisms in Civil Engineering Materials
ME C117 – Structural Aspects of Biomaterials
ME C223 – Polymer Engineering
MSE C214 – Micromechanics

Energy Technology Emphasis
Core Program plus the following:

Junior Year	*Fall*	*Spring*
MSE 136 – Materials in Energy Technologies	4	-
Courses approved for emphasis in Energy Technology[1]	-	3
Total	**4**	**3**
Senior Year		
MSE 117 – Properties of Dielectric and Magnetic Materials	-	3
Courses approved for emphasis in Energy Technology[1]	6	6
Total	**6**	**9**

[1]Electives in the Energy Technology Emphasis must include one MSE 120 series course; at least six units in the topic of "energy and society," taken from the following approved list. (Consult the *General Catalog* for prerequisites.)

CE 107 – Climate Change Mitigation
Earth and Planetary Science C180 – Air Pollution;

and at least six units in "energy generation and conversion," taken from the following approved list. (Consult the *General Catalog* for prerequisites.)

Chem E 176 – Principles of Electrochemical Processes
NE 161 – Nuclear Power Engineering
NE 180 – Introduction to Controlled Fusion
Energy Resources Group 120 - Renewable Resources for Electric Generation

The remaining three units may be taken from either topical area. Substitution of courses not on this list requires adviser approval.

Nanomaterials Emphasis
Core Program plus the following:

Junior Year	*Fall*	*Spring*
EE 143 – Microfabrication Technology	4	-
MSE 140 – Nanomaterials for Scientists and Engineers	-	3
Total	**4**	**3**
Senior Year		
MSE 117 – Properties of Dielectric and Magnetic Materials	-	3
MSE 125 – Thin-Film Materials Science	-	3
Courses approved for emphasis in Nanomaterials[1]	6	3
Total	**6**	**9**

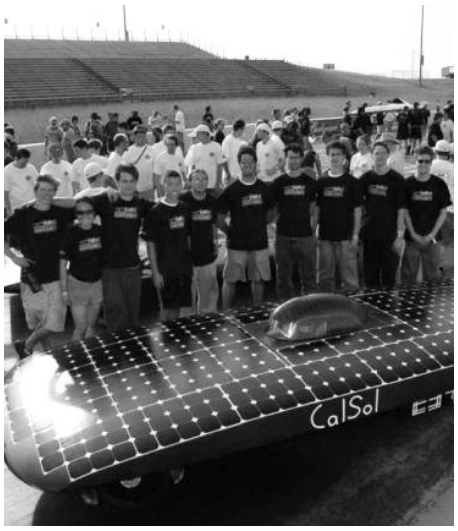
[1] Electives in the Nanomaterials emphasis must be taken from the following approved list. (Consult the *General Catalog* for prerequisites.) Substitution of courses not on this list requires adviser approval.

Chem E 179 – Process Technology of Solid State Materials Devices
ME 118 – Introduction to Nanotechnology and Nanoscience
ME 119 – Introduction to Microelectromechanical Systems

General Emphasis
Core Program plus the following:

Junior Year	*Fall*	*Spring*
Technical Electives[1]	3	3
Total	**3**	**3**
Senior Year		
Technical Electives[1]	6	9
Total	**6**	**9**

[1] Technical electives in the General Emphasis must include one MSE 120 series course and eighteen additional units of upper division technical electives, chosen to meet individual educational objectives. A minimum of three courses, selected in agreement with the faculty adviser, should constitute an integrated program in another engineering field, physics, chemistry, or mathematics. The technical electives cannot include: any course taken on a P/NP basis; BioE 100; CS 194, 195, C195; E 100, C111, 140, 191, 193, 196; EE 194; IEOR 190 series.



Mechanical Engineering

6189 Etcheverry Hall #1740
(510) 642-1338
me.berkeley.edu
Chair: Albert P. Pisano, Ph.D.

Department Overview

Mechanical engineers serve society by solving problems in transportation, energy, the environment, and human health. The activity of mechanical engineers extends from investigation of physical phenomena governing the behavior of our surroundings to the manufacture and evaluation of products. The technical domain of the mechanical engineering profession encompasses topic areas, including acoustics, automatic control, bioengineering, combustion, cryogenics, design, dynamics, energy conversion, engines, environment, heat transfer, lubrication, mass transfer, manufacturing, materials processing, mechanics of solids and fluids, mechanisms, petroleum, plasma dynamics, propulsion, thermodynamics, vibration, and wave propagation.

Undergraduate Program

The undergraduate program in mechanical engineering seeks to provide students with a broad education emphasizing an excellent foundation in scientific and engineering fundamentals. Students are supplied with the tools to synthesize their engineering knowledge and apply it to the analysis of performance and design. The capstone of the program is the senior design experience, which assists in developing a deep understanding of the process.

To meet the needs of its two primary constituencies — industry and mechanical engineering graduate programs — the objectives of the undergraduate program are to produce graduates who:

• Vigorously engage in post-baccalaureate endeavors, whether in engineering graduate study, engineering practice, or the pursuit of other fields, such as science, law, medicine, business, or public policy.

• Apply their mechanical engineering education to address the full range of technical and societal problems with creativity, imagination, confidence, and responsibility.

• Actively seek out positions of leadership within their profession and their community.

• Serve as ambassadors for engineering by exhibiting the highest ethical and professional standards and communicating the importance and excitement of this dynamic field.

This program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD21202-4012; telephone: (410) 347-7700.

Joint Major Programs

The department offers two joint major programs with either the Department of Nuclear Engineering or the Department of Materials Science and Engineering. See the Joint Majors section of this announcement for detailed descriptions and curricula.

Mechanical Engineering Minor

The department offers a minor in mechanical engineering that is open to all students not majoring in ME who have completed the necessary prerequisites for the minor requirements. Information is available on the student information section of the mechanical engineering website or at the department office.

Graduate Study

Increasing demands for technical competence in engineering make it advisable for many students of suitable scholarship to continue their studies for an advanced degree. The department offers a complete program of graduate study and research in both traditional and innovative areas within mechanical engineering. It also participates in several interdisciplinary programs.

See the department website for more information on graduate study.

The major areas of study are bioengineering, computer mechanics, controls and dynamics, energy and the environment, fluid and solid mechanics, manufacturing process, materials and design, microelectromechanical systems (MEMS), nanosystems, ocean engineering, and thermodynamics. Active interdisciplinary programs include bioengineering and environmental engineering. Degrees offered are M.S., M.Eng., Ph.D., and D.Eng. A professional-type terminal M.S. degree is also offered.

For further details and specific areas of concentration, please consult the graduate admission section of the mechanical engineering website or contact the department.

Five Year B.S./M.S. Program

For Berkeley mechanical engineering undergraduates only, the program allows our students to broaden their expertise in the major. It encourages an interdisciplinary focus, with concentrations in mechanical engineering and allied fields such as the sciences or other engineering tracks, as well as complementary fields of study like business, law, or public policy. It is structured to foster future leaders in industry with its focus on interdisciplinary technical skills as well as broader understanding of the legal and social contexts of technology development and use. Unlike our standard M.S.-only program, it is coursework only and students are not required to choose a specialized area of study. Students are also given a chance to choose between a comprehensive exam and a project report at the end of their studies.

Facilities

The Department of Mechanical Engineering maintains state of the art laboratories in Etcheverry Hall and Hesse Hall on campus, as well as the Richmond Field Station.

Faculty and researchers collaborate extensively and share facilities with the Orthopaedic Surgery, Neurological Surgery, Radiology, and Medicine units at UC San Francisco; the VAMC in San Francisco; Lawrence Livermore National Laboratory; and Lawrence Berkeley National Laboratory.

The department's other state of the art facilities include:

- The Automatic Control and Instrumentation Laboratory
- The Berkeley Expert Systems Technology Laboratory
- The Berkeley Instructional Technology Studio (BITS)
- The Berkeley Manufacturing Institute. Five main laboratory areas comprise the BMI:

(1) The Design Studio

(2) The Computer-Aided Design and Manufacturing Laboratory

(3) The Rapid Prototyping Studio

(4) The Laboratory for Manufacturing and Sustainability (LMAS). The Precision Manufacturing Laboratory

(5) The Integrated Manufacturing Laboratories

- Laboratories devoted to bioengineering include:

(1) The Biofluid Mechanics Laboratory

(2) The Orthopaedic Biomechanics Laboratory

(3) The Biomaterials Testing Facility

(4) The Bio-Thermal Engineering Laboratory

- The Combustion Laboratories
- The Composite Materials Laboratory
- The Computational Fluid Dynamics Laboratory
- The Computational Marine Mechanics Laboratory (CMML)
- The Computational Solid Mechanics Laboratory (CSML)
- The Computer Mechanics Laboratory (CML)
- The UC Berkeley Electro-Mechanical Design Laboratory
- The Environmental Restoration Laboratory
- The Fluid Mechanics Laboratories
- The Heat and Mass Transfer Laboratory
- The Human Engineering and Robotics Laboratory
- The Impact and Biomechanics Laboratory
- The Impact and Wave Propagation Laboratory
- The Laser Thermal Laboratory
- The Mechanical Behavior of Materials Laboratories
- The MEMS Analysis and Design Laboratory
- The Multiphase Transport Laboratory
- The Nanobiology Laboratory
- The Nanoengineering Laboratory (NanoLab)
- The Nano/Microsystems Laboratory
- The Richmond Model-Testing Facility
- The Robotics and Motion Control Laboratory
- The research conducted at the Surface Mechanics and Tribology Laboratory (SMTL)
- The Telerobotics and Neurology Unit
- The Transport in Porous Media Laboratories
- The Vehicle Dynamics and Control Laboratory (VDL)
- The Vibration and Dynamics Laboratories

For more information on research facilities, see the laboratories section of the mechanical engineering website.

Undergraduate Program in Mechanical Engineering		118-125 Units*
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
Engineering 7 – Introduction to Computer Programming[1]	-	4
Engineering 10 – Engineering Design and Analysis[1]	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[2]	4	-
Reading and Composition Course from List B[2]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	<1>
Total	**15-16**	**16-17**
Sophomore Year		
Engineering 28 – Graphic Communication in Engineering	3	-
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
ME 40 – Thermodynamics	-	3
ME C85 – Introduction to Solid Mechanics	-	3
Physics 7B – Physics for Scientists and Engineers	4	-
Additional Humanities/Social Sciences Courses[2]	3-4	3-4
Total	**14-15**	**13-14**
Junior Year		
EE 100 – Electronic Techniques for Engineering	-	4
ME 104 – Engineering Mechanics II (Dynamics)	3	-
ME 106 – Fluid Mechanics	3	-
ME 108 – Mechanical Behavior of Engineering Materials	4	-
ME 109 – Heat Transfer	-	3
ME 132 – Dynamic Systems and Feedback	-	3
Technical Electives[3]	3	3
Additional Humanities/Social Sciences Courses[2]	3-4	3-4
Total	**16-17**	**16-17**
Senior Year		
ME 102A – Experimentation and Measurement	4	-
ME 102B – Mechanical Engineering Design	-	3
ME 107 – Mechanical Engineering Laboratory	-	3
Technical Electives[3]	6	6
Upper Division Electives[4]	3-4	3
Total	**13-14**	**15**

[1] If prerequisites are met, students are encouraged to take E 7 during the fall and E 10 during the spring.

[2] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[3] Technical Electives: 18 units of technical electives are required, of which at least 15 must be from upper division elective mechanical engineering-sponsored courses. Of these 15 units, three units must be an elective design course selected from the following list:

- E 128 – Advanced Engineering Design Graphics
- ME 101 – High Mix/Low Volume Manufacturing
- ME 110 – Introduction to Product Development
- ME 119 – Introduction to MEMS
- ME 128 – Computer-Aided Mechanical Design
- ME 130 – Design of Planar Machinery
- ME 135 – Design of Microprocessor-Based Mechanical Systems
- ME 142 – Heating, Air Conditioning, and Refrigeration
- ME 145 – Computer-Aided Thermal Design (if ME 145 is used as a quantitative science elective, it can also be used toward the 15 units of upper division ME units, but not as a design elective; another design course must be chosen from the approved list.)
- ME 165 – Ocean-Environment Mechanics

Also, one of the technical elective courses must be taken from the quantitative science list below:

- E 117* – Methods of Engineering Analysis
- E 170 – Introduction to Modeling and Simulation
- E 177* – Advanced Programming with MATLAB
- Math 128A – Numerical Analysis
- ME 145* – Computer-Aided Thermal Design (if ME 145 is used as a quantitative science elective, it can also be used toward the 15 units of upper division ME units, but not as a design elective; another design course must be chosen from the approved list.)
- ME C180* – Engineering Analysis Using the Finite Element Method

Four of these courses (noted with asterisks) are sponsored by mechanical engineering, and if taken can count simultaneously toward the 15 unit requirement and quantitative science requirement.

Students can receive up to three units of technical elective credit for work on a research project in ME H194, Honors Undergraduate Research. Any upper division course taught by mechanical engineering faculty may be used as part of the 15 units of upper division mechanical engineering courses. The other technical elective units can be chosen from courses in engineering, physical science, mathematics, or statistics.

Technical Electives cannot include: any course taken on a P/NP basis; BioE 100; CS 194, 195, C195; E 100, C111, 140, 191, 193, 196; EE 194; IEOR 190 series.

Physical science is defined to include physics, chemistry, biochemistry, chemical engineering, and the biological sciences.

Only one lower division course taken from the approved list of Lower Division Technical Electives can be used to satisfy part of the technical elective requirement. This list consists of the following courses: Astronomy 7A; Biology 1A, 1B; Chemistry 1B, 5; CE 70; Molecular and Cell Biology 11, 32 (32L not required); and Statistics 20, 25; or any lower division technical course required by another major in the College of Engineering.

[4] Upper Division Electives: This course can be chosen at the student's discretion. This includes all upper division non-technical courses.

***A minimum of 120 units is required for graduation.**

Mechanical Engineering Options Electives

Technical Electives

The following groups of elective courses should help undergraduates focus on their specific professional goals. The electives need not be from any single group. Courses designated as special topics in the *General Catalog* and graduate level courses may require College approval by petition.

Biomechanical Engineering:
Biology 1A; BioE C212, C213, 214, 290A; EE C145B, 145L, 145M; Integrative Biology 131, 132; ME C117, 127, 133, 134, 135, 142, 166, C176; Molecular and Cell Biology 32*, 130

Combustion:
CE 111; Chem E 140, 141, 142; E 117; ME 140, 151

Computer-Aided Engineering:
E 128, 177; ME 128

Controls:
E 177; EE 120, 128; ME 133, 134, 135, 146, 175, 190L, 190Y, 146

Energy:
ME 140, 142, 145, 146

Environmental Engineering:
CE 104N, 111, 173, 175; ME 110, 140, 142, 151, 165, 173; NE 162; Suggested non-technical courses: Architecture 100A, 100B, 140; Geography 144

Fluid Mechanics and Aeronautics:
E 117; CE 131; ME 133, 134, 151, 163, 165, 167, 173, 175, 185

General Mechanical Engineering:
E 117, 128; ME 110, 133, 134, 165, 173, 175

Heat and Mass Transfer:
Chem E 150B, 171; E 117; ME 140, 142, 151

Materials Processing and Manufacturing Management:
E 120; IEOR 115, 140, 170, 180; ME 101, 110, 122, 127, 128, 133, 134, 151

Mechanical Engineering Design:
E 128; ME 110, 118, 119, 127, 128, 130, 133, 134, 135, 142, 151, 165, C176

Mechatronics:
ME 101, 128, 130, 133, 134, 135

Microelectromechanical systems (MEMS):
ME 118, 119

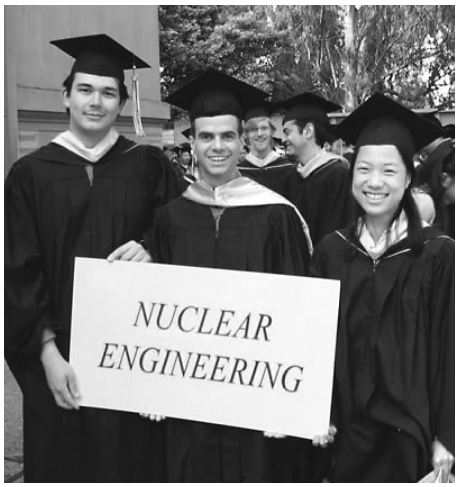
Nuclear Engineering:
ME 134, 151, 173; NE 101, 120, 150; Physics 137A

Ocean Engineering:
ME 101, 127, 128, 134, 164, 165, 167; CE 120, 180

Robotics and Automation:
EE C125; IEOR 140, 170; ME 101, 133, 134, 135, 170, 175

Theoretical and Applied Mechanics:
E 117; Mathematics 104; ME 127, 133, 134, 163, 165, 170, 173, 175, C180, 185

* ME students are not required to take Molecular and Cell Biology 32L with Molecular and Cell Biology 32.



Nuclear Engineering

4153 Etcheverry Hall, #1730
(510) 642-5010
nuc.berkeley.edu
Chair: Per F. Peterson, Ph.D.

Department Overview

Nuclear Engineering is concerned with the understanding of nuclear processes and their application in the energy, environmental, manufacturing, materials processing, and medical industries. The teaching and research programs encompass three broad areas: nuclear energy, nuclear waste and materials management, and bionuclear engineering and radiological physics. Much of the curriculum is devoted to the analysis, design, and development of fission and fusion power reactors; the nuclear fuel cycle, including radioactive waste management and disposal; and applications of nuclear science in instrumentation, radiation detection and protection, medical diagnosis and treatment, and materials behavior. Safety and environmental impacts are considered from a risk and systems viewpoint.

Undergraduate Program

The undergraduate curriculum in nuclear engineering is designed to prepare students for a career in industry, national laboratories, or state or federal agencies. The program leading to the B.S. in Nuclear Engineering emphasizes educational experience in several fields of engineering, leading to a concentration on nuclear engineering courses in the upper division.

Rather than the degree in nuclear engineering, undergraduate students may instead elect a joint major degree program, which combines Nuclear Engineering with Electrical Engineering and Computer Sciences, or with Materials Science and Engineering, or with Mechanical or Chemical Engineering. Compared with the single major program, the joint major programs are more strictly structured and offer fewer opportunities for nontechnical electives. On the other hand, they do afford ambitious students an opportunity to qualify in two fields of engineering with little or no loss in time during their undergraduate careers. Details on the joint major programs are to be found in the Joint Majors section of this announcement.

The mission of the undergraduate program in nuclear engineering is to prepare our students to begin a lifetime of technical achievement and professional leadership in academia, government, national laboratories, and industry. To achieve this mission, the NE undergraduate program is designed to produce graduates who:

• Possess solid knowledge of the fundamental mathematics and natural sciences (both physical and biological) that provide the foundation for engineering applications.

• Understand nuclear processes and the application of general natural science and engineering principles to the analysis and design of nuclear and related systems of current and/or future importance to society.

• Have strong independent learning, analytical, and problem-solving skills, with special emphasis on design, communication, and an ability to work in teams.

• Understand the broad social, ethical, safety, and environmental context within which nuclear engineering is practiced.

• Are aware of the importance of, and opportunities for, lifelong learning.

The B.S. program in nuclear engineering is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: (410) 347-7700.

Joint Major Programs

Joint major programs are available with either the Department of Electrical Engineering and Computer Sciences or the Department of Materials Science and Engineering. See the Joint Majors section of this announcement for detailed descriptions and curricula. Nuclear Engineering also has a joint major program with Chemical Engineering. See the College of Chemistry Announcement for detailed descriptions of that joint major.

Nuclear Engineering Minor

The department offers a minor in nuclear engineering that is open to all students who are not majoring in NE and who have completed the necessary prerequisites for the minor requirements. Information is available at the department office.

Graduate Study

The graduate program is divisible into 11 areas, each representing an important aspect of nuclear technology. Coursework and research opportunities are available in each area.

Applied Nuclear Physics

Applied Nuclear Physics is concerned with the low-energy nuclear physics and interaction of radiation with matter important to nuclear chemistry, nuclear technology, and applications. Research programs include fundamental nuclear physics measurements for applied purposes and the development of advanced detectors and methodologies, in addition to the application of nuclear techniques in a wide range of studies. Current emphasis is on experimental and

modeling studies in support of neutrino mass measurements, the design of methodologies and systems to counter the possible transport of clandestine nuclear materials, and applications in the biomedical and radiological sciences.

Bionuclear and Radiological Physics

This program is concerned with the biological effects of radiation, dosimetry, radiation shielding, radiation protection, and the development of methods based on the application of radiation for the prevention, diagnosis, and treatment of illness and disease. Research is focused on medical imaging, boron neutron capture therapy, and radioactive tracers, computerized tomography, positron emission tomography, and magnetic resonance imaging.

Nuclear Materials and Chemistry

This area of study is devoted to understanding the many causes of materials degradation and failure in nuclear technology. Specific emphasis is on the behavior of nuclear fuels, cladding and structural materials in nuclear fission and fusion environments where radiation damage and corrosion are the overarching concerns. This research combines computational, experimental, and theoretical techniques to investigate the dynamic response of nuclear materials. The Nuclear Materials Laboratory uses thermogravimetric techniques with microbalances to investigate the hydriding and oxidation of nuclear reactor core materials and positron annihilation spectroscopy to characterize the microstructural changes in irradiated structural steels. In addition to understanding the performance of nuclear fuels and materials in current nuclear fission plants, the materials aspects of new fuel element designs and advanced nuclear fuels and structural material systems are investigated.

Energy and the Environment

This program focuses on renewable and clean energy techniques, particularly solar, wind, and biomass sources. Research and teaching activities focus on the performance, efficiency, economics, and dissemination of these energy systems. The Renewable and Appropriate Energy Laboratory (RAEL) in Etcheverry Hall supports this program area.

Fission Reactor Analysis

Graduate study encompasses the synthesis of the basic components of nuclear technology in the engineering and design of nuclear reactors. Problems of heat removal, stress analysis, reactor dynamics and control, and nuclear reactor safety are considered.

Fusion Science and Technology

This specialty deals with current approaches to the design of a fusion reactor. For both the magnetic and the inertial confinement schemes, problems of particle confinement, plasma heating, reactor materials, fusion reactor neutronics, safety, and environmental impacts are analyzed. Experimental facilities for plasma research include the Berkeley Compact Toroid Experiment (BCTX) on the campus and several large collaborative efforts at Lawrence Livermore National Laboratory and Lawrence Berkeley Laboratory. The Rotating Target Neutron Source (RTNS), an accelerator-based fusion neutron source, is also on the Berkeley campus and is used for fusion neutron studies.

Nuclear Thermal Hydraulics

This area of study is devoted to improving the current understanding of heat and mass transfer, and fluid mechanics processes that transport energy and mass in nuclear systems and govern system performance and safety. Key phenomena studied include conduction, convection, and radiation heat transfer, phase change, and single- and multi-phase flows. In addition to water used to transport heat in present-day reactors, study in this area also covers gas, molten salt, and liquid metal coolants for advanced fission and fusion systems, as well as transport and mixing processes that occur inside reactor containment structures and in environmental systems.

Laser, Particle Beam, and Plasma Technologies

This area of study includes a broad spectrum of new technologies related to charged particles and fields. The topical areas range from interaction of lasers with plasmas to charged particle beam physics, to plasma technologies such as lighting and material processing discharges. Applications range from laser-plasma interactions to discharges for lighting, material modification and microelectronic fabrication; and from microwave-beam interactions for microwave sources and plasma heating to plasma devices such as thrusters, and ion and electron beam sources.

Fuel Cycles and Radioactive Waste

This area of study is devoted to the development of methods and models (theoretical and/or experimental) for analyzing processes that handle nuclear materials from cradle to grave. The methods and models developed are used for evaluating environmental impacts, economics, and proliferation resistance of a fuel cycle, and for designing an optimized fuel-cycle system. Basic research includes the development of deterministic models and the experimental data to support them, probabilistic methods and models, and optimization methods. An initial focus is on the Advanced Fuel Cycle Initiative, which aims at improved use of repository capacity for civilian-spent nuclear fuel from the current light-water reactors, with help of systems for separation and transmutation of problematic radionuclides.

Risk, Safety, and Systems Analysis

This area of study is devoted to the development of methods and models and the acquisition of empirical data for assessing the impacts of large-scale technological systems on public health and safety, and on the environment. Basic research includes the development of deterministic models and the experimental data to support them, probabilistic methods and models, and optimization methods. An initial focus is on Generation IV nuclear energy systems, which integrate the nuclear fuel cycle in terms of high-level radioactive waste disposal, nuclear reactor safety, overall fuel cycle analysis and economics, and safeguards and security. Other complex large-scale systems considered include biological systems, ecological systems, information systems, and electric distribution systems.

Ethics and the Impact of Technology on Society

This program focuses on the emerging ethical and technical issues arising in biotechnology, nanotechnology, information technology, and nuclear technology. The program examines how philosophy, religion and art, and natural and social science can shed light on these issues, as well as how individual and societal values are affected by these technologies.

Further information may be obtained by consulting the website or contacting the department.

Facilities

The facilities of the department include the Nuclear Waste Research Laboratory, the Renewable and Appropriate Energy Laboratory (RAEL), the Advanced Nuclear Engineering Computational Laboratory, several research and teaching laboratories, and well-equipped mechanical and electronic shops. The neutronics laboratory includes the RTNS 14 Mev neutron source, a variety of radiation-analysis instrumentation, and subcritical multiplying assemblies. The RTNS is also being used for the study of boron-neutron capture therapy. Experimental facilities for the study of thermal problems include two-phase flow and transient-boiling apparatus, and for the study of materials problems include a variety of equipment for high-temperature and high-vacuum experiments. Some nuclear engineering students participate in research at Lawrence Berkeley and Livermore National Laboratories, Los Alamos National Laboratory, and the National Renewable Energy Laboratory (NREL).

Undergraduate Program in Nuclear Engineering		118-122 Units*
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Computer Programming for Scientists & Engineers	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> NE 92, Issues in Nuclear Engineering (recommended)	<2>	-
Total	**15-17**	**15**
Sophomore Year		
E 45 – Properties of Materials	3	-
EE 40 – Introduction to Microelectronic Circuits or EE 100 – Electronic Techniques for Engineering	-	4
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
First and Second Additional Humanities/Social Sciences Courses[2]	3-4	3-4
Total	**15**	**15**
Junior Year[4]		
E 115 – Engineering Thermodynamics	4	-
E 117 – Methods of Materials Analysis	3	-
NE 101 – Nuclear Reactions and Radiation	4	-
NE 104 – Radiation Detection Lab	-	3
NE 150 – Nuclear Reactor Theory	-	3
Technical Electives[3]	-	9
Third Additional Humanities/Social Sciences Course[1,2]	3-4	-
Total	**14-15**	**15**
Senior Year		
NE 170 – Nuclear Design	-	3
Technical Electives[3]	14	9
Fourth Additional Humanities/Social Sciences Course[1]	-	3-4
Total	**14**	**15-16**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Students must take one course with ethics content. This may be fulfilled within the Humanities/Social Sciences Electives requirement by taking one of the following courses: Anthropology 156B; BioE 100; Environmental Science, Policy and Management 161, 162; Geography 31; Interdisciplinary Studies 61, 100E; International and Area Studies 105; Legal Studies 19AC; Philosophy 2, 104, 107; Political Science 108A; Sociology 116, 123.

[3] 32 technical elective units must include at least 17 units of upper division NE courses. Remaining technical elective units must be fulfilled by taking upper division courses in engineering and science. The technical elective units cannot include: any course taken on a P/NP basis; BioE 100; CS 194, 195, C195; E 100, C111, 140, 191, 193, 196; EE 194; IEOR 172, 190 series.

[4] Students must consult with and obtain approval from their faculty adviser no later than the fall semester of their junior year for their choices of technical elective courses.

***A minimum of 120 units is required for graduation.**

Upper Division Technical Electives

The following groups of electives should help undergraduate students focus their choices on specific professional goals. The electives selected need not be from any single group.

Beam and Accelerator Applications:
Physics 110A/B (or EE 117), 129 A/B, 139, 142; NE 155, 180

Bionuclear Engineering:
BioE C165; EE 120 (EE 20N is a prerequisite for this course), 145B; NE 107, 162

Fission Power Engineering:
ME 106, 109 (Chem E 150A may be substituted for ME 106 and 109); NE 120, 124, 155, 161, 167, 175

Fusion Power Engineering:
Physics 110A/B, 142; NE 120, 180, 155

Homeland Security and Nonproliferation:
Chemistry 143, Physics 110A/B, 111, NE 107, 130, 155, 175

Materials in Nuclear Technology:
MSE 102, 104, 112, 113; NE 120, 124, 155, 161

Nuclear Fuel Cycles and Waste Management:
Chem E 150A/B; E 120; Energy Resources Group 151; MSE 112; NE 120, 124, 155, 161, 175

Radiation and Health Physics:
NE 120, 155, 162, 180

Risk, Safety and Systems Analysis:
CE 193; Chem E 150A; E 120; IEOR 166; NE 120, 124, 155, 161, 167, 175

Completed in 2007, the 285,000 square foot Stanley Hall houses the Department of Bioengineering and the California Institute for Quantitative Biosciences (QB3) and was designed to promote multidisciplinary interaction and innovation. The atrium (pictured) forms the heart of the building. ▶

Joint Major Programs

The joint major programs are designed for students who wish to undertake study in two major areas of engineering in order to qualify for employment in either field or for positions in which competence in two fields is required. These curricula include the core courses in each of the major fields. While they may require increased course loads, they can be completed in four years, and both majors are shown on the student's transcript.

The joint major programs currently offered are listed below. Each program is described in details on the proceeding pages.

- Bioengineering and Materials Science and Engineering
- Electrical Engineering and Computer Sciences and Materials Science and Engineering
- Electrical Engineering and Computer Sciences and Nuclear Engineering
- Materials Science and Engineering and Mechanical Engineering
- Materials Science and Engineering and Nuclear Engineering
- Mechanical Engineering and Nuclear Engineering

Admission to a Joint Major Program

Freshman Admits. Students admitted to the College of Engineering as freshmen may apply to a joint major once they have completed two semesters at UC Berkeley. Historically, students need a GPA of 3.0 or higher to be admitted to a joint major program. (Students in the Engineering Undeclared program are eligible to declare a joint major if they have a GPA of at least 2.0 and are in good academic standing.) Engineering students considering a joint major are advised to meet with their adviser in the Engineering Student Services Office to learn more about the process. See coe.berkeley.edu/joint-majors for more information.

Junior Transfer Applicants. Junior transfer applicants may apply directly to one of the joint major programs. Transfer students interested in a joint major should carefully review the specific graduation requirements for the program before submitting their application. See the College's Prospective Students webpage for more details on transfer admission and requirements.

Freshman and Transfer applicants interested in a joint major with chemical engineering must apply to the College of Chemistry.

Chemical Engineering Joint Major Programs

In conjunction with the College of Chemistry, the College of Engineering offers two joint major programs:

- Chemical Engineering and Materials Science and Engineering
- Chemical Engineering and Nuclear Engineering

Current UC Berkeley students interested in one of the chemical engineering joint majors should contact the College of Chemistry for information on how to change into their college. Full details on the chemical engineering joint major program and curricula can be found in the *Announcement of the College of Chemistry*.

Bioengineering and Materials Science and Engineering Joint Major Program

The Department of Bioengineering offers a joint major with Materials Science and Engineering for students who have an interest in the field of biomaterials. The broad-based curriculum includes exposure to fundamental courses in engineering and life sciences and will allow students to understand the interface between the two major fields. Students who graduate with this joint major will successfully compete for jobs in the field of biomaterials in academia, industry, and government.

Joint Major Program in Bioengineering and Materials Science and Engineering		127-132 Units
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
Chemistry 3A and 3AL – Chemical Structure and Reactivity ***or*** Chemistry 112A – Organic Chemistry[1]	-	5
E 7 – Introduction to Computer Programming for Scientists & Engineers ***or*** CS 61A – Structure and Interpretation of Computer Programs	-	4
E 10 – Engineering Design and Analysis ***or*** BioE 10 – Introduction to Biomedicine for Engineers	3-4	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[2]	4	-
Freshman Seminar[3] <Optional>	1	<1>
Total	**16-17**	**17-18**
Sophomore Year		
Biology 1A and 1AL – General Biology	-	5
Chemistry 3B – Chemical Structure and Reactivity ***or*** Chemistry 112B – Organic Chemistry[1]	3	-
E 45, Properties of Materials	3	-
EE 40 – Introduction to Microelectronic Circuits, EE 100 – Electronic Techniques for Engineering, ***or*** BioE 101 – Instrumentation in Biology and Medicine	-	4
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Reading and Composition Course from List B[2]	-	3-4
Total	**14**	**16-17**
Junior Year		
BioE 102 – Biomechanics	4	-
BioE 104 – Biological Transport Phenomena	-	4
Chemistry 135 – Chemical Biology; MCB 102 – Survey of the Principles of Biochemistry and Molecular Biology, ***or*** MCB 110 – General Biochemistry and Molecular Biology	3	-
Chemistry 120B – Physical Chemistry, Chemistry C130/MCB C100A – Biophysical Chemistry, E 115 – Engineering Thermodynamics, ***or*** BioE C105B/ME C105B – Thermodynamics and Biothermodynamics	3	-
Molecular and Cell Biology 130A – Cell and Systems Biology	-	4
MSE 102 – Bonding, Crystallography and Crystal Defects	3	-
MSE 104 – Characterization of Materials	-	4
BioE 100 or First Additional Humanities/Social Sciences Course with Ethics Content[2,4]	-	3-4
Second Additional Humanities/Social Sciences Course[2]	3-4	-
Total	**16**	**15-16**
Senior Year		
BioE 110 – Biomedical Physiology for Engineers BioE 115 – Cell Biology, ***or*** MSE 130 – Experimental Materials Science	3-4	-
BioE 116 – Cell and Tissue Engineering BioE C117 – Structural Aspects of Biomaterials	-	4
BioE C118 – Biological Performance of Materials	4	-
BioE 121 – Introduction to Micro and Nanobiotechnology: BioMEMS, BioE 150 – Introduction to Bionanoscience and Bionanotechnology, MSE 111 – Properties of Electronic Materials, MSE 112 – Corrosion, ***and/or*** MSE 113 – Mechanical Behavior of Engineering Materials *(Choose 2 of 5)*	3-4	3-4
MSE 151 – Polymeric Materials	3	-
Bioengineering Design Project or Research[5]	-	4
Third and Fourth Additional Humanities and Social Sciences Courses[2]	3-4	3-4
Technical Elective[6]	-	3
Total	**16-17**	**17**

[1] Chemistry 112A/B is intended for students majoring in chemistry or a closely related field and is more intensive than Chemistry 3A/3B. **Note:** Prerequisites to Chemistry 112A/B include Chemistry 1A and 1B (or 4A and 4B). Pre-Med students should take Chemistry 3B and 3BL or 112B, and Biology 1B.

[2] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[3] At least one semester of BioE 24 is required. Students may also select BioE 24 or 25, MSE 24, or E92 for the optional second semester.

[4] See Bioengineering Ethics Content List on page 16.

[5] See course list on page 16.

[6] Choose from the following approved list (consult the *General Catalog* for prerequisites): BioE 113, 116, C117, 121, H194; MSE 103, 111, 112, 113.

Electrical Engineering and Computer Sciences and Materials Science and Engineering Joint Major Program

The materials used in integrated circuits run the gamut to include semiconductors, insulators, metals, polymers, and composites, motivating students to seek the joint major in electrical engineering and computer sciences and material science and engineering. The curriculum in this joint major is designed to provide a fundamental background in both disciplines, so that students will be conversant in all aspects of materials selection and design to optimize electronic, optical, and magnetic properties in engineering applications. Students completing this joint major program will find career options in all branches of the microelectronics industries.

Joint Major Program in Electrical Engineering and Computer Sciences and Materials Science and Engineering		**126-133 Units**
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Computer Programming for Scientists & Engineers	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	<1>
Total	**15-16**	**16-17**
Sophomore Year		
CS 61A – Structure and Interpretation of Computer Programs	4	-
CS 61B – Data Structures	-	4
E 45 – Properties of Materials	3	-
EE 40, Introduction to Microelectronic Circuits	-	4
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
First Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**18-19**	**16**
Junior Year		
CS 61C – Machine Structures ***or*** EE 20N – Structure and Interpretation of Systems and Signals	4	-
E 115 – Engineering Thermodynamics ***or*** Physics 112 – Statistical and Thermal Physics	4	-
EE 105 – Microelectronic Devices and Circuits	-	4
EE 126 – Probability and Random Processes, Statistics 25 – Introduction to Probability and Statistics for Engineers, ***or*** Statistics 134 – Concepts of Probability	-	3-4
MSE 102 – Bonding, Crystallography, and Crystal Defects	3	-
MSE 103 – Phase Transformations and Kinetics	-	3
MSE 104 – Characterization of Materials	-	4
Physics 137A – Quantum Mechanics	4	-
Second Additional Humanities/Social Sciences Courses[1]	-	3-4
Total	**15**	**17-19**
Senior Year		
EE 117 – Electromagnetic Fields and Waves	4	-
EE 140 – Linear Integrated Circuits ***or*** EE 141 – Digital Integrated Circuits	3	-
MSE 111 – Properties of Electronic Materials ***or*** EE 130 – Integrated Circuit Devices	-	4
MSE 130 – Experimental Materials Science	3	-
Physics 141A – Solid State Physics	3	-
Technical Electives[2]	-	6
Third and Fourth Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**16-17**	**13-14**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] Technical electives must include two courses: (1) one course from the following: CS 150; EE 119, 143; and (2) at least three units from the MSE 120 series courses.

Electrical Engineering and Computer Sciences and Nuclear Engineering Joint Major Program

Joint Major Program in Electrical Engineering and Computer Sciences and Nuclear Engineering	123-127 Units	
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry	4	-
Chemistry 4A – General Chemistry and Quantitative Analysis		
CS 61A – Structure and Interpretation of Computer Programs	4	-
CS 61B – Data Structures	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	-	4
Total	**15**	**16**
Sophomore Year		
E 45 – Properties of Materials	3	-
EE 20N – Structure and Interpretation of Systems and Signals	4	-
EE 40 – Introduction to Microelectronic Circuits	-	4
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List B[1]	-	4
Total	**15**	**16**
Junior Year		
E 115 – Engineering Thermodynamics	4	-
EE 120 – Signals and Systems	4	-
EE 126 – Probability and Random Processes, Statistics 25 – Introduction to Probability and Statistics for Engineers, Statistics 134 – Concepts of Probability	-	3-4
NE 101 – Nuclear Reactions and Radiation	4	-
NE 104 – Radiation Detection Lab	-	3
NE 150 – Nuclear Reactor Theory	-	3
First Humanities/Social Sciences Course[1]	3-4	-
Second and Third Additional Humanities/Social Sciences Courses[1]	-	6-8
Total	**15-16**	**15-18**
Senior Year		
EE 105 – Macroelectronic Devices and Circuits	4	-
EE 117 – Electromagnetic Fields and Waves	-	4
NE 170A – Nuclear Engineering Design	-	3
Technical Electives[2]	8	9
Fourth Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**15-16**	**16**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

Students must take one course with ethics content. This may be fulfilled within the Humanities/Social Sciences Requirement by taking one of the following courses: Anthropology 156B; BioE 100; E 124, 195; Environmental Science, Policy, and Management 161, 162; Geography 31; Interdisciplinary Studies 61, 100E; International and Area Studies 105; Legal Studies 19AC; Philosophy 2, 104, 107; Political Science 108A; Sociology 116, 123.

[2] Technical Electives include:

• At least nine units of upper division nuclear engineering courses from the following groups. The groups are presented to aid undergraduate students in focusing their choices on specific professional goals, however, the electives selected need not be from any single group. Courses listed from other departments in these groups may be taken to provide further depth but may not be used toward the nine units.

Beam and Accelerator Applications: Physics 110A/B (or EE 117), 129, 139, 142; NE 155, 180

Bionuclear Engineering: BioE C165; EE 120 (EE 20N is a prerequisite for this course), 145B; NE 107, 162

Fission Power Engineering: ME 106, 109 (Chem E 150A may be substituted for ME 106 and 109); NE 120, 124, 155, 161, 167, 175

Fusion Power Engineering: Physics 110A/B, 142; NE 120, 180, 155

Homeland Security and Nonproliferation: Chemistry 143, Physics 110A/B, 111, NE 107, 130, 155, 175

Materials in Nuclear Technology: MSE 102, 104, 112, 113; NE 120, 124, 155, 161

Nuclear Fuel Cycles and Waste Management: Chem E 150A/B; E 120; Energy Resources Group 151; MSE 112; NE 120, 124, 155, 161, 175

Radiation and Health Physics: NE 120, 155, 162, 180

Risk, Safety and Systems Analysis: C E 193; Chem E 150A; E 120; IEOR 166; NE 120, 124, 155, 161, 167, 175

• At least eight units of upper division EECS courses from the following lists:

Electromagnetics and Plasmas: 119, 239

Electronics: EE 130, 140, 141, 143; CS 150

Power Systems and Control: EE 113, 120, 128

Materials Science and Engineering and Mechanical Engineering Joint Major Program

Students interested in the mechanical behavior of materials have the option of pursuing a joint major in materials science and engineering and mechanical engineering. The curriculum addresses key fundamentals of both disciplines, preparing students in materials selection and design for structural and functional applications. Students completing this joint major enter professional positions in the aerospace, automotive, energy, and manufacturing industries, along with many others.

Joint Major Program in Materials Science and Engineering and Mechanical Engineering		**128-134 Units**
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Computer Programming for Scientists & Engineers	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)	<1>	<1>
Total	**15-16**	**16-17**
Sophomore Year		
E 28 – Graphics Communication in Engineering	3	-
E 45 – Properties of Materials	-	3
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
ME 40 – Thermodynamics	-	3
ME C85 – Introduction to Solid Mechanics	3	-
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
First and Second Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**17-18**	**17-18**
Junior Year		
EE 100 – Electronic Techniques for Engineering	-	4
ME 104 – Engineering Mechanics II (Dynamics)	3	-
ME 106 – Fluid Mechanics	3	-
ME 109 – Heat Transfer	3	-
ME 132 – Dynamic Systems and Feedback	-	3
ME 108 – Introduction to Engineering Materials ***or*** MSE 113 – Mechanical Behavior of Engineering Materials	3	-
MSE 102 – Bonding, Crystallography, and Crystal Defects	3	-
MSE 103 – Phase Transformation and Kinetics	-	3
MSE 104 – Characterization of Materials	-	4
Technical Electives[2]	-	3
Third Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**18-19**	**17**
Senior Year		
ME 102A – Experimentation and Measurement	4	-
ME 102B – Mechanical Engineering Design	-	3
ME 107 – Mechanical Engineering Laboratory	-	3
MSE 112 – Corrosion	-	3
MSE 130 – Experimental Materials Science	3	-
Technical Electives[2]	3	6
Fourth Additional Humanities/Social Sciences Course[1]	3-4	-
Total	**13-14**	**15**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

[2] A total of 12 upper division technical elective units are required. These must include six units of upper division Mechanical Engineering courses, one of which must be from the following list: ME 101, 110, 119, 128, 130, 135, 142, 145, 161, or 165. In addition, three units must be from the MSE 120 series.

Technical electives cannot include: any course taken on a P/NP basis; BioE 100; CS 194, 195, C195; E 100, C111, 140, 191, 193, 196; EE 194; IEOR 190 series.

Materials Science and Engineering and Nuclear Engineering Joint Major Program

The interface between materials science and engineering and nuclear engineering is an especially challenging and rewarding one, giving students in this joint major an exciting range of options. With a sound curriculum steeped in the fundamentals, the joint major program prepares students to fully understand the behavior of materials in a reactor environment, including their design and optimization. Students completing this joint major will successfully compete for positions in the energy sector.

Joint Major Program in Materials Science and Engineering and Nuclear Engineering	125-131 Units	
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry 4-Chemistry 4A – General Chemistry and Quantitative Analysis		
E 7 – Introduction to Applied Computing	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
<Optional> Freshman Seminar or E 92 (Survey Course)[2]	<1>	<1>
Total	**15-16**	**16-17**
Sophomore Year		
E 45 – Properties of Materials	-	3
EE 40 – Introduction to Microelectronic Circuits EE 100 – Electronic Techniques for Engineering	-	4
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
ME C85 – Introduction to Solid Mechanics	3	-
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
First and Second Additional Humanities/Social Sciences Courses[1]	6-8	-
Total	**17-19**	**15**
Junior Year		
E 115 – Engineering Thermodynamics	4	-
MSE 102 – Bonding, Crystallography, and Crystal Defects	3	-
MSE 103 – Phase Transformation and Kinetics	-	3
MSE 104 – Characterization of Materials	-	4
NE 101 – Nuclear Reactions and Radiation	4	-
NE 104 – Radiation Detection Lab	-	3
NE 150 – Introduction to Nuclear Reactor Theory	-	3
Technical Electives[3]	3	-
Third and Fourth Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**17-18**	**16-17**
Senior Year		
MSE 111 – Properties of Electronic Materials	-	4
MSE 112 – Corrosion	-	3
MSE 113 – Mechanical Behavior of Materials	-	3
MSE 130 – Experimental Materials Science	3	-
NE 120 – Nuclear Materials	4	-
NE 170A – Nuclear Engineering Design	-	3
Technical Electives[3]	9	-
Total	**16**	**13**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases H/SS courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

Students must take one course with ethics content. This may be fulfilled within the Humanities/Social Sciences (H/SS) requirement by taking one of the following courses: Anthropology 156B; BioE 100; E 124; Environmental Science, Policy, and Management 161, 162; Geography 31; Interdisciplinary Studies 61, 100E; International and Area Studies 105; Legal Studies 19AC; Philosophy 2, 104, 107; Political Science 108A; Sociology 116, 123.

[2] NE 39 also recommended.

[3] Technical electives must include at least 9 units of upper division NE courses and at least 3 units from the MSE 120 series courses.

Mechanical Engineering and Nuclear Engineering Joint Major Program

This program was established to address the interface between the two major fields. It is intended for nuclear engineering students interested in mechanical design and heat transfer, as well as for mechanical engineering students who wish to further their knowledge of nuclear radiological systems and processes. Its objective is to provide students with a strong and competitive background in both majors, leading to professional careers in nuclear and radiation-based industries, or to pursue graduate study in nuclear engineering and other engineering disciplines or related fields such as medicine and physics.

Joint Major Program in Mechanical Engineering and Nuclear Engineering		127-132 Units
Freshman Year	*Fall*	*Spring*
Chemistry 1A – General Chemistry ***or*** Chemistry 4A – General Chemistry and Quantitative Analysis	4	-
E 7 – Introduction to Applied Computing	-	4
E 10 – Engineering Design and Analysis	3	-
Mathematics 1A – Calculus	4	-
Mathematics 1B – Calculus	-	4
Physics 7A – Physics for Scientists and Engineers	-	4
Reading and Composition Course from List A[1]	4	-
Reading and Composition Course from List B[1]	-	4
Total	**15**	**16**
Sophomore Year		
E 28, Graphics Communication and Engineering	3	-
Mathematics 53 – Multivariable Calculus	4	-
Mathematics 54 – Linear Algebra and Differential Equations	-	4
ME 40, Thermodynamics	-	3
ME C85, Introduction to Solid Mechanics	-	3
Physics 7B – Physics for Scientists and Engineers	4	-
Physics 7C – Physics for Scientists and Engineers	-	4
Additional Humanities/Social Sciences Courses[1]	3-4	3-4
Total	**14-15**	**17-18**
Junior Year		
EE 40 – Introduction to Microelectronic Circuits ***or*** EE 100 – Electronic Techniques for Engineering	-	4
ME 104 – Engineering Mechanics II (Dynamics)	3	-
ME 106 – Fluid Mechanics	-	3
ME 108 – Introduction to Engineering Materials	4	-
ME 109 – Heat Transfer	3	-
ME 132 – Dynamic Systems and Feedback	-	3
NE 101 – Nuclear Reactions and Radiation	4	-
NE 150 – Nuclear Reactor Theory	-	3
Additional Humanities/Social Sciences Course[1]	3-4	3-4
Technical Electives[2]	-	3
Total	**17-18**	**19-20**
Senior Year		
ME 102A – Experimentation and Measurement	4	-
ME 102B – Mechanical Engineering Design	-	3
ME 107 – Mechanical Engineering Laboratory	-	3
NE 104 – Radiation Detection Lab	-	3
NE 170A – Nuclear Engineering Design	-	3
Additional Humanities/Social Sciences Course[1]	3-4	-
Technical Electives[2]	4	3
Total	**14-15**	**15**

[1] The Humanities/Social Sciences (H/SS) requirement includes two approved reading and composition courses and four additional approved courses, with which a number of specific conditions must be satisfied. This chart shows the courses in recommended order, but in most cases these courses can be taken at any time during the program as long as prerequisites are met. See coe.berkeley.edu/hssreq for complete details and a list of approved courses.

Students must take one course with ethics content. This may be fulfilled within the Humanities/Social Sciences Electives requirement by taking one of the following courses: Anthropology 156B; BioE 100; E 124, 130AC, 195; Environmental Science, Policy and Management 161, 162; Geography 31; Interdisciplinary Studies 61, 100E; International and Area Studies 105; Legal Studies 19AC; Philosophy 2, 104, 107; Political Science 108A; Sociology 116, 123.

[2] Technical elective units include at least six units of upper division elective Mechanical Engineering courses and six units of upper division Nuclear Engineering courses.


SUTTON GALLERY

Additional Programs and Affiliated Groups

Applied Science and Technology Graduate Group

230 Bechtel Engineering Center
ast.coe.berkeley.edu

This graduate group is administered by the College of Engineering. The program has three major areas of emphasis: applied physics, engineering science, and mathematical sciences. This program awards the Doctor of Philosophy degree. In addition, students who have been admitted to the program may also apply for the Designated Emphasis in Nanoscale Science and Engineering (DE NSE), the emphasis (DE) in Energy, Science, and Technology (DE EST), and the newly created Designated Emphasis in Computational Science and Engineering (DE CSE). Students usually apply for the DE during their first or second year of study.

Faculty associated with the program are drawn from several departments within the College of Engineering, as well as from the Departments of Physics, Chemistry, Chemical Engineering, and Mathematics. Topics of interest include the novel properties and applications of nanostructures, thin films and interface science, microelectromechanical systems (MEMS), nanoscale science and engineering, short-wavelength coherent radiation, X-ray microimaging for the life and physical sciences, plasma physics and plasma-assisted materials processing, laser-induced chemical processes, laser probing of complex reacting systems, ultrafast phenomena, particle accelerators, nonlinear dynamics, chaotic systems, numerical methods, and topics in computational fluid mechanics and reacting flows.

Graduate research in the AS&T program benefits from state-of-the-art experimental facilities on the Berkeley campus and at the Lawrence Berkeley National Laboratory. Among these facilities are the National Center for Electron Microscopy, with the world's highest-resolution high-voltage microscope; a microfabrication lab for student work involving lithography, MEMS, ion implantation, and thin-film deposition; an integrated sensors laboratory; femtosecond laser laboratories; optical, electrical, and magnetic resonance spectroscopies; short wavelength laser and X-ray research laboratories; an unparalleled variety of material, chemical, and surface science analytic equipment; and a soft X-ray synchrotron dedicated to materials, chemical, and biological research based on high-brightness and partially coherent radiation. The interdisciplinary, collaborative nature of the AS&T Program provides ample opportunity to develop new research directions by making the best possible use of these facilities and the other research instrumentation available to AS&T faculty.

Students in the AS&T program take courses drawn largely from regular departments with the concurrence of faculty advisers. In addition, faculty associated with the graduate group offer additional courses.

Admission. The complete application, including transcripts, GRE scores, TOEFL score (if previous instruction was not in English), three letters of reference, and a statement of academic and professional goals, is due on December 1st for the following fall semester. To obtain application information, students should contact the Applied Science and Technology Graduate Group, 230 Bechtel Engineering Center #1702, University of California, Berkeley; Berkeley, CA 94720-1702; telephone: (510) 642-8790; email: ast.program@coe.berkeley. edu; website: ast.coe.berkeley.edu.

Computational Science and Engineering

cse.berkeley.edu

By combining high-performance computing, mathematical modeling, scientific and engineering theory, and analysis of large scale data bases of observations, the Designated Emphasis in Computational Science and Engineering (DE CSE) promises to bring a new paradigm to interdisciplinary research and education. The DE will educate doctoral students to effectively conduct computationally intensive research across many fields of science and engineering. Students will be exposed to the breadth of research in CSE on campus and at LBNL. The DE, like a minor, is listed on the academic transcript (e.g., Ph.D. in Applied Science and Technology with Designated Emphasis in Computational Science and Engineering). Requirements include three courses, participation in a group seminar, and a CSE-related thesis. For a list of participating programs, please visit http://cse.berkeley.edu/admissions. For more information about the DE CSE, contact Professor James Demmel (demmel@cs.berkeley.edu), Chair of the DE CSE Executive Committee, 564 Soda Hall, #1776, University of California, Berkeley, Berkeley CA 94720-1776; email cse@coe.berkeley.edu.

Center for Entrepreneurship & Technology

448 Sutardja Dai Hall
cet.berkeley.edu

The Center for Entrepreneurship & Technology (CET) is a CITRIS-affiliated academic center and industry partnership within UC Berkeley's College of Engineering. Since its establishment in 2005, the Center's mission has been to equip engineers and scientists with the skills to lead, innovate, and commercialize technology in the global economy. Through teaching, programs, network building, and research interlaced with strong industry participation, CET teaches entrepreneurship as it relates to individual venture creation and to innovation within existing entities.

Taught with the help of entrepreneurs, industry executives, and venture capitalists, CET undergraduate courses combine classroom study with experiential learning. The CET undergraduate course sequence empowers students to become technology leaders through classroom and hands-on study. Upon completion of the sequence, a student may go on to start a venture, lead innovation within an established company, or pursue a professional graduate degree. The core courses of the sequence are IEOR 191, Technology Entrepreneurship; IEOR 171, Technology Leadership; and E198, the A. Richard Newton Distinguished Innovator Lecture Series.

The CET graduate program provides students an opportunity to work on real-world problems within emerging industry. The graduate curriculum comprises the CET Venture Lab, focused on students' individual ventures, and the CET Industry Lab, which allows students to focus on larger-scale problems.

In addition to its undergraduate and graduate initiatives, CET develops a robust ecosystem of professionals throughout the world who share knowledge, insight, and real-world experience with our students. The A. Richard Newton Global Technology Leaders Conference, sponsored by the Kauffman Foundation, brings together luminaries from a range of disciplines to address the world's most significant challenges and to identify pathways to their solution. The Berkeley-Tsinghua Global Technology Entrepreneurship Center fosters innovation and entrepreneurship at both institutions through increased interaction and understanding of innovation between China and the United States. The Global Venture Lab (GVL) network is an alliance of academic institutions sharing common research and educational programs that are likely to lead to new industry and economic growth. Finally, CET Technical Briefs are a series of papers that address significant problems while influencing the creation of new industry.

Management of Technology Certificate Program

462 Sutardja Dai Hall
cet.berkeley.edu

The Management of Technology Program is an interdisciplinary certificate program co-sponsored by the College of Engineering and the Haas School of Business, offering graduate students academic courses which examine aspects of the process of bringing high technology products to the marketplace. By addressing both management and technology issues, MOT provides students with classroom experience which translates to workplace skills. To earn an MOT certificate, students must take at least 9 units of coursework, chosen from over 40 classes and workshops, including at least one interdisciplinary team project class. MOT also sponsors internships, fellowships and lectures. MOT course list and program details are found on the website: mot.berkeley.edu

Nanoscale Science and Engineering

nano.berkeley.edu/educational/DEGradGroup.html

Doctoral students interested in pursuing interdisciplinary research focused on nanoscale science and engineering (NSE) may additionally join the growing Designated Emphasis (DE) in Nanoscale Science and Engineering (NSE), administered by the NSE Graduate Group. The DE, like a minor, is listed on the academic transcript (e.g., Ph.D. in Mechanical Engineering with Designated Emphasis in Nanoscale Science and Engineering). Requirements include one core course, two electives, participation in a group seminar, and a nano-related thesis. Students usually apply for the DE during their first or second year of study. For a list of participating programs, please visit nano.berkeley.edu/de/programs.html. For more information about the NSE DE, contact the program coordinator Avi Rosenzweig, NSE Graduate Group, Berkeley Nanosciences and Nanoengineering Institute, 550 Sutardja Dai Hall #1726, University of California, Berkeley; Berkeley, CA 94720-1726; email: nanoinstitute@lists.berkeley.edu

Chemical Engineering

cheme.berkeley.edu

Studies in Chemical Engineering are offered by the Department of Chemical Engineering in the College of Chemistry. For information regarding the programs of study available, consult the *Announcement of the College of Chemistry.* Inquiries may be directed to the College of Chemistry Undergraduate Office (420 Latimer Hall #1460) for undergraduate students, and to the Chemical Engineering Graduate Office (201 Gilman Hall #1462) for graduate students.

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Contact Information

College of Engineering

coe.berkeley.edu

Office of the Dean:
320 McLaughlin Hall #1700
(510) 642-5771

Engineering Student Services (Undergraduate):
230 Bechtel Engineering Center #1702
(510) 642-7594

Engineering Student Services (Graduate):
See department or program of interest

Instructional Units

Applied Science and Technology Graduate Group,
230 Bechtel Engineering Center #1702
ast.coe.berkeley.edu
Bioengineering
306 Stanley Hall #1762
bioeng.berkeley.edu
Bioengineering Graduate Group,
306 Stanley Hall #1762
bioegrad.berkeley.edu
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www.ce.berkeley.edu
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eecs.berkeley.edu
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me.berkeley.edu
Nuclear Engineering,
4153 Etcheverry Hall #1730 (Graduate Admissions, 4149 Etcheverry Hall #1730)
nuc.berkeley.edu

Other Offices

Admissions (graduate): Graduate Division,
309 Sproul Hall #5900
grad.berkeley.edu
Admissions (undergraduate):
Office of Undergraduate Admissions,
110 Sproul Hall #5800
admissions.berkeley.edu
Berkeley Engineering Alumni Relations
312 McLaughlin Hall #1704
bears@berkeley.edu
coe.berkeley.edu/alumni
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208 McLaughlin Hall #1722
bef@coe.berkeley.edu
coe.berkeley.edu/support-the-college
(510) 642-2487
Berkeley Nanosciences and Nanoengineering Institute
550 Sutardja Dai Hall #1726
nano.berkeley.edu
Career Center
2111 Bancroft Way #4350
career.berkeley.edu
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cet.berkeley.edu
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101 Bechtel Engineering Center #1702
ejc.berkeley.edu
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financialaid.berkeley.edu
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333 Campbell Hall #2922
fss.berkeley.edu

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356 Sutardja Dai Hall #1764
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230 Bechtel Engineering Center
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Third Floor, Sproul Hall #5900
grad.berkeley.edu
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coe.berkeley.edu
Summer Undergraduate Program in Engineering Research at Berkeley (SUPERB)
230 Bechtel Engineering Center #1702
coe.berkeley.edu/cues/superb
Transportation Engineering, see Civil and Environmental Engineering, Institute of Transportation Studies

Other Information Sources

General Catalog, Berkeley
May be purchased from the Cal Student Store, Attn: Mail Order Department, University of California, Berkeley; Berkeley, CA 94720-4504
catalog.berkeley.edu
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Schedule of Classes
Available online; go to schedule.berkeley.edu
EECS Undergraduate Notes
A copy may be obtained from the Center for Undergraduate Matters, 205 Cory Hall
eecs.berkeley.edu/Programs/Notes/newcurric-notes.html
EECS Graduate Notes
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Access to Student Records

To implement the University Policy Governing Disclosure of Information to Students and Access to Student Records, Engineering Student Services has established the following procedures, applicable to former students, as well as to students currently enrolled.

Public Records

Inquiries made in person or by phone will be answered only in case of clear necessity. Unless specifically requested by the student not to do so, the following information is considered public and will be provided to individuals upon written request: verification of registration; major; date of admission, attendance, graduation, or proposed date of graduation; honors and scholarships received.

Confidential Records

The following information in the student's file and maintained by Engineering Student Services is considered confidential and will be released only pursuant to the procedures which follow:

1. Office of the Registrar's Dean's Card
2. Correspondence to, about, and from student
3. Scholarship action, recommendations, and grants-in-aid information
4. Student photograph
5. Degree check
6. Student Information Card
7. Transcripts from other schools attended, including high school
8. Copies of petitions
9. Work slips
10. Medical excuses
11. Notes of interviews with deans and curriculum advisers
12. Records of telephone calls
13. Curriculum questionnaire
14. Semester evaluations by Office of the Registrar
15. Copy of admission application and essay
16. Copy of educational test scores
17. Engineering study-list

Effective September 1974, records of engineering graduates are maintained for five years after graduation. After that date, only items 1 to 5 will be retained. Records of inactive students are maintained for five years starting from last date of enrollment. After five years, only items 1 to 12 will be retained. Semester grade reports and dean's cards from the Office of the Registrar for enrolled students are replaced when updated copies are received.

Access to Records

The following staff personnel have access to student records: staff of Engineering Student Services and Dean's Offices, Engineering deans, faculty of the college, and the ombudspersons. Other campus personnel have access to records on a need-to-know basis determined by the associate dean of Engineering Student Services.

Procedures for Access to Records

By Student. Students will be given an appointment to review their records after written request. No more than two working days will be required to provide the records for review. Letters of recommendation dated before January 1, 1975, are not subject to disclosure.

A page charge of $.25 per copy will be assessed for material duplicated from the student records. Material will be duplicated at the time of the request, if it can be done without delaying service to others. Otherwise, the students will be given a time to return for their copies, within two days from the time of the request.

By Third Party. Access to records by a third party (other than those listed under Access to Records above) is available only with the written consent of the student. Information may be released in case of emergency without the consent of the student (for example, by judicial order), to accrediting organizations, in case of health and safety emergencies, or for research purposes. For additional information about such disclosures, consult the printed directive, Policy Governing Disclosures of Information from Student Records, available upon request.

The form delegating the student's authority to release information is available at the desk of each staff member. The third party to whom information is made available must also complete a form which is available at the desk of each staff member and which requires date, reason for review of record, and signature. Furthermore, the third party must also agree that information received must not be given to another party without written consent of the student.

Challenge and Hearing. A staff member of Engineering Student Services will explain information in a student's record upon request. If the student believes that the record is in error or misleading, an appointment will be made with the associate dean. If, after that appointment, the student is still not satisfied with the explanation, an appeal may be made to the dean of the College of Engineering. If after these appointments the matter is still not resolved, a further appeal may be made to an ombudsperson.

Challenge of grades and evaluation of student work is not within the scope of the hearing.

Nondiscrimination Statement

The University of California, in accordance with applicable Federal and State law and the University's nondiscrimination policies, does not discriminate on the basis of race, color, national origin, religion, sex (including sexual harassment), gender identity, pregnancy/childbirth and medical conditions related thereto, disability, age, medical condition (cancer-related), ancestry, marital status, citizenship, sexual orientation, or status as a Vietnam-era veteran or special disabled veteran. This nondiscrimination statement covers admission, access, and treatment in University programs and activities. It also covers faculty (Senate and non-Senate) and staff in their employment.

The Campus Climate and Compliance (CCAC) office may be contacted regarding discrimination issues. Sexual or racial harassment, hostile environment, LGBT, hate or bias issues may be directed to Nancy Chu, Director and Title IX/VI Compliance Officer, at tixco@berkeley.edu or (510) 643-7985. Disability issues may be directed to the Disability Resolution Officer at esc@berkeley.edu or (510) 642-2795. More information may also be found at ccac.berkeley.edu.

The Jeanne Clery Act

The University of California Police Department at Berkeley maintains an annual campus safety report in compliance with the Jeanne Clery Act. It includes the year's campus crime statistics, information about safety services, crime prevention strategies, emergency preparedness guidelines, and more. For a copy of this report, *Safety Counts,* please contact the University of California Police Department, Berkeley, by phone at (510) 642-6760 or email at police@berkeley.edu. You can also download a PDF of *Safety Counts* at police.berkeley.edu/safetycounts.

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