

---

# Engineering Sciences

*Professor Zhigang Suo, Director of Undergraduate Studies*

In recognition of the pivotal role of technology in our society, Harvard is committed to broadly educating engineers "... to become leaders in an expanding economy based increasingly upon the utilization of science in an economic manner for human needs" ("Report of the Panel on the McKay Bequest to the President and Fellows of Harvard College," Vannavar Bush, Chair, 1950).

The concentration in Engineering Sciences is flexibly structured for a diversity of educational and professional objectives. For students who are planning to work as practicing engineers or who may be preparing for careers in business, education, government, law, or medicine, and for those whose career objectives may be less specific, the concentration provides an ideal framework for a well-rounded technical and scientific education.

The technologies engineers create are changing at an amazing rate, but the fundamental tools of engineering change more slowly. The Harvard engineering curriculum emphasizes a solid background in the applied sciences and mathematical analysis, with ample opportunity to learn about state-of-the-art technologies. Students also gain experience in the engineering design process, the unique engineering activity which requires creative synthesis as well as analysis to fulfill specified needs.

Two different Engineering Science degrees are offered at Harvard College: the Bachelor of Arts (AB) and the Bachelor of Science (SB). The objectives of the Engineering Sciences programs are to provide students a solid foundation in engineering within the setting of a liberal arts college for preparation for a diverse range of careers in industry and government or for advanced work in engineering, business, law or medicine. The program allows each student to specialize in one of five areas within the engineering sciences: biomedical sciences and engineering; electrical and computer engineering; engineering physics; environmental sciences and engineering; or mechanical and materials science and engineering. It enables the acquisition of a broad range of skills and attitudes drawn from the humanities, social sciences and sciences, in addition to engineering, which enhance engineering knowledge and which will contribute to future leadership and technical success.

The AB degree consists of 16 half-courses. This degree can provide adequate preparation for the practice of engineering and for graduate study in engineering, and it is an excellent preparation for careers in other professions (business, law, medicine, etc.). Because it requires fewer concentration courses than the SB degree, the AB program is appropriate for students who wish to take advantage of the great breadth of Harvard College course offerings. There are five options leading to the AB degree in engineering sciences: Biomedical Sciences and Engineering; Electrical and Computer Engineering; Engineering Physics; Environmental Sciences and Engineering; Mechanical and Materials Sciences and Engineering.

The SB degree program requires a minimum of twenty half-courses, and the level of technical concentration is comparable to engineering programs at other major universities and technical institutions. In particular, the SB program is recognized by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc. (ABET), the national accreditation agency for engineering programs in the US. While accredited as preparation for the immediate practice of engineering, it is also good preparation for graduate study in engineering, the sciences, and other professions. The four options in this program are Biomedical Sciences and Engineering; Electrical Engineering and Computer Science; Environmental Sciences and Engineering; and Mechanical and Materials Science and Engineering. Students electing the SB degree may petition for a ninth term or additional year as described in the section 6g of the SB program requirements below.

The engineering science curriculum is highly structured, with advanced courses building on the knowledge acquired in math, science, and introductory engineering science courses. Concentrators are encouraged to complete the common prerequisite course sequence in their first two years at Harvard. This includes Math (through 1a and 1b; plus 21a and 21b, 23a and 23b, or, most preferably, Applied Mathematics 21a and 21b), Physics (through 11a and 11b or 15a and 15b), and Computer Science 50. Students are cautioned that it is more important to derive a solid understanding of these basic subjects rather than to complete them quickly without thorough knowledge; this material is extensively used in many subsequent courses. If in doubt, it may be wise to enroll in the Math 1 sequence rather than proceed to Math 21a or 23 with marginal preparation. Applied Mathematics 21a and 21b and Physics 11a and 11b are recommended for most engineering concentrators. SB degree candidates may want to complete additional requirements in their first two years.

The AB and SB programs share many course requirements, and there is some flexibility in moving between these programs, particularly through the first two years. To get an early sample of engineering course work, entering students are invited to enroll in Engineering Sciences 6 (environmental engineering), Engineering Sciences 50 (electrical engineering), Engineering Sciences 51 (mechanical engineering), and Engineering Sciences 53 (biomedical engineering). These introductory courses have minimal prerequisites, and have been very popular with prospective engineering concentrators. Engineering Sciences 50 and 51 have extensive hands-on laboratory sections.

Students who are interested in concentrating in engineering sciences should contact the Assistant Director of Undergraduate studies, Dr. Marie Dahleh, ([mdahleh@seas.harvard.edu](mailto:mdahleh@seas.harvard.edu)), to set up an appointment to learn more about the program.

## OPTIONS

### **Bachelor of Arts in Engineering Sciences**

- Biomedical Sciences and Engineering
- Electrical and Computer Engineering
- Engineering Physics
- Environmental Sciences and Engineering
- Mechanical and Materials Science and Engineering

### **Bachelor of Science in Engineering Sciences**

- Biomedical Sciences and Engineering
- Electrical Engineering and Computer Science
- Environmental Sciences and Engineering
- Mechanical and Materials Science and Engineering

---

**REQUIREMENTS**  
**Bachelor of Arts (AB) in Engineering Sciences**  
**16 half-courses**

1. *Required courses:*
  - a. *Mathematics:*
    - i. Math 1a and 1b.
    - ii. Applied Mathematics 21a and 21b; Mathematics 21a and 21b; or Mathematics 23a and 23b.
  - b. *Physics:* Physics 11a and 11b, 15a and 15b, or 16 and 15b.
  - c. *Computer Science:* Computer Science 50.
  - d. Required courses and electives in area of specialization (see item 6 below).
2. *Sophomore Forum:* Sophomore year. Non-credit. Spring term.
3. *Thesis:* Not required.
4. *General Examination:* None.
5. *Other information:*
  - a. Advanced Placement credit in Math 1a or 1b can be included in satisfying the requirement of 16 half courses, thus potentially reducing the number of required courses to 14 or 15. Credit for additional courses such as Math 21a or 21b does not further reduce the number of required courses. Moreover, in cases when a course can satisfy both an elective and a requirement of a specialization, the total number of courses is also not reduced. In these cases, additional electives must be taken.
  - b. By prior approval, other advanced undergraduate or graduate courses, as well as courses at MIT, can be used to satisfy general requirements and specialization requirements and electives. Electives alternative to those listed in the specializations may be counted for credit upon prior petition and approval.
  - c. Students taking Engineering Sciences 6, 50, 51, or 53 during the freshman or sophomore year can count one of these courses as an elective in any specialization that does not include that course as a requirement.
  - d. Highest Honors are decided by vote of the Committee on Undergraduate Studies, taking into account the student's course selection and achievement. Typically, a recommendation for Highest Honors requires superior performance in an ambitious set of advanced courses or an excellent thesis.
  - e. *Pass/Fail:* None of the courses used to satisfy concentration requirements may be taken Pass/Fail.
  - f. *Plan of Study:* Concentrators are required to file an approved departmental Plan of Study and to keep their plan up to date in subsequent years. Plan of Study forms may be obtained from the Academic Office (Pierce 110) or from the School of Engineering and Applied Sciences (SEAS) website ([www.seas.harvard.edu/academic/undergrad-study/engineeringsciences/index.html](http://www.seas.harvard.edu/academic/undergrad-study/engineeringsciences/index.html)).
6. *Areas of Specialization*
  - a. *Biomedical Sciences and Engineering*
    - i. *Required for all tracks, three half-courses:*  
Engineering Sciences 53 and 145  
Life Sciences 1a
    - ii. *Required for Mechanical track, four half-courses:*  
Engineering Sciences 120, 123, and 181  
Either Engineering Sciences 154 or Physics 123

- iii. *Required for Electrical track, four half-courses:*
  - Engineering Sciences 150, 154, and 156
  - Either Engineering Sciences 148 or 149
- iv. *Required for Chemical and Materials track, four half-courses:*
  - Engineering Sciences 123, 181, and 190
  - Physical Sciences 1
- v. *Approved Electives, two half-courses:*
  - Engineering Sciences 91r (one term only), 120, 122, 123, 128, 130, 148, 149, 157, 159, 181, 190, 216, 217, 220, 221, 240
  - Either Applied Mathematics 101 or Engineering Sciences 150
  - Only one of Engineering Sciences 139, 143, or 144
  - Either Engineering Sciences 154 or Physics 123
  - Physics 136, 140, 143a, 151, 153
  - One from Physical Sciences 1, Chemistry 17, 20
  - Applied Mathematics 105a or 105b.
- b. *Electrical and Computer Engineering*
  - i. *Required, five half-courses:*
    - Engineering Sciences 150, 151, 154, and 156
    - One from Computer Science 141, Engineering Sciences 173 or 174
  - ii. *Approved Electives, four half-courses:*
    - Engineering Sciences 91r (one term only), 120, 123, 145, 148, 157, 158, 159, 173, 174, 181, 190, 201, 202, 203, 258
    - Computer Science 51, 141, 143, 144r, 148, 161, 175, 246r, 283
    - Applied Mathematics 105a, 105b, 121, 147
    - Applied Physics 195
    - Chemistry 160
    - Physics 123, 143a, 153.
- c. *Engineering Physics*
  - i. *Required for all tracks, four half-courses:*
    - Either Physics 143 or Chemistry 160
    - Either Engineering Sciences 181 or Physics 181
    - Applied Physics 190
    - One from Applied Mathematics 105a, 105b, 111, or 147.
  - ii. *Required for Materials, Optoelectronics, and Photonics track, three half-courses:*
    - Engineering Sciences 173 and 174
    - One from Applied Physics 195, Physics 195, or Engineering Sciences 120.
  - iii. *Required for Earth and Planetary Physics track, three half-courses:*
    - One from Engineering Sciences 123, 162, Earth and Planetary Sciences 131, 132
    - One from Engineering Sciences 120, Earth and Planetary Sciences 108, 166, 167
    - One from Earth and Planetary Sciences 121, 161, Astronomy 135, 145.
  - iv. *Approved Electives, two half-courses:*
    - Engineering Sciences 91r (one term only), 120, 123, 125, 128, 162, 173, 174
    - Applied Mathematics 105a, 105b, 111, 115, 120, 147
    - Applied Physics 195
    - Astronomy 135, 145
    - Earth and Planetary Sciences 108, 109, 131, 132, 133, 161, 166, 167, 171
    - Physics 123, 140, 153, 175, 195.

- d. *Environmental Sciences and Engineering*
- i. *Required, seven half-courses:*  
 Engineering Sciences 6  
 Physical Sciences 1  
 Life Sciences 1a  
 One from Earth and Planetary Sciences 108, Engineering Sciences 162 or 167  
 One from Earth and Planetary Sciences 133, Engineering Sciences 168 or 169  
 One from Engineering Sciences 150; Statistics 110; Applied Mathematics 101, 105a, 105b, 111, or 147  
 One from Engineering Sciences 123, Earth and Planetary Sciences 131 or 132
  - ii. *Approved Electives, two half-courses:*  
 Engineering Sciences 91r (one term only), 103, 123, 162, 165, 167, 168, 181, 220, 261, 262, 268  
 Earth and Planetary Sciences 107, 108, 109, 131, 132, 133  
 Either Engineering Sciences 154 or Physics 123
- e. *Mechanical and Materials Sciences and Engineering*
- i. *Required, seven half-courses:*  
 Engineering Sciences 120, 123, 125, 181, and 190  
 One from Applied Mathematics 105a, 105b, 111, or 120  
 One from Engineering Sciences 50, 151, 154, or Physics 123.
  - ii. *Approved Electives, two half-courses:*  
 Engineering Sciences 91r (one term only), 96, 128, 142, 145, 151, 156, 159, 162, 173, 174  
 Applied Physics 195  
 Chemistry 160  
 Earth and Planetary Sciences 108, 131, 132  
 Physics 143a.

**Bachelor of Science (SB) in Engineering Sciences**  
**20 half-courses**

1. *Required courses:*
  - a. *Mathematics:* Mathematics 1a and b; Applied Mathematics 21a and 21b, Mathematics 21a and 21b, or Mathematics 23a and 23b.
  - b. *Physics:* Physics 11a and 11b, 15a and 15b, or 16 and 15b.
  - c. *Chemistry:* Life Sciences 1a and Physical Sciences 1.
  - d. *Computer Science:* Computer Science 50.
  - e. *Electronics:* At least one from Engineering Sciences 154, Computer Science 141, or Physics 123.
  - f. *Mechanics:* At least one from Engineering Sciences 120, 123, or 125.
  - g. *Materials:* At least one from Engineering Sciences 181, 190, Physics 143a, Chemistry 160, or Applied Physics 195.
  - h. *Applied Mathematics:* At least one from Applied Mathematics 105a, 105b, 106, 107 or 111.
  - i. *Probability and Statistics:* At least one from Applied Mathematics 101 or 121, Engineering Sciences 150, or Statistics 110.
  - j. *Engineering Design (two courses):* Engineering Sciences 96 (ordinarily taken during the spring term of the junior year), and Engineering Sciences 100hf or 100 (see item 3 below).

- k. At least four additional half-courses chosen to develop an area of specialization (see items 6a-d).

*Note:* Students entering Harvard with secondary school preparation that places them beyond the level of any of the required courses listed above may substitute appropriate advanced level courses. However, all SB programs must include a minimum of twenty approved half-courses and meet the overall ABET guidelines (see items 7a-b).

2. *Sophomore Forum:* Sophomore year. Non-credit. Spring term.
3. *Tutorial:* Required. Engineering Sciences 96 and Engineering Sciences 100hf or Engineering Sciences 100.
4. *Thesis:* Required: An individual engineering design project is an essential element of every SB program and is undertaken, ordinarily, during the senior year as part of Engineering Sciences 100hf. Faculty supervised reading and research is an important aspect of this requirement.
5. *General Examination:* None.
6. *Areas of specialization:*
  - a. *Biomedical Sciences and Engineering—Mechanical, Electrical, or Chemical & Materials tracks*
    - i. *Required for all tracks:* Engineering Sciences 53, Engineering Sciences 145.
    - ii. *Required for Mechanical track:* Engineering Sciences 120, 123, 181, 190.
    - iii. *Required for Electrical track:* Engineering Sciences 150, 154, 156; either Engineering Sciences 148 or 149.
    - iv. *Required for Chemical & Materials track:* Chemistry 17 or 20; Engineering Sciences 123, 181, 190.
    - v. *Suggested:*  
 Engineering Sciences 120, 122, 123, 128, 130, 148, 149, 156, 157, 159, 181, 190, 216, 217r, 220, 221, 240  
 One from Engineering Sciences 6, 50, or 51  
 Either Engineering Sciences 139 or 144  
 Physics 136, 140, 143a, 151, 153  
 Applied Physics 225  
 Either Chemistry 17 or 20  
 MCB 80 (formerly Biological Sciences 80) (only acceptable if Engineering Sciences 148 is taken also)

*Note:* Engineering Sciences 125 may not be taken for credit in the biomedical sciences and engineering specialization.
  - b. *Electrical Engineering and Computer Science*
    - i. *Required:* Computer Science 51; Engineering Sciences 150, 151, 154, 156.
    - ii. *Suggested:*  
 Computer Science 141, 143, 144r, 148, 161, 175  
 Applied Mathematics 121, 147  
 Engineering Sciences 50, 51, 139 or 144 (but not both), 145, 148, 157, 158, 159, 173, 174  
 Physics 143a or Chemistry 160  
 Physics 153  
 By prior approval, advanced-level MIT courses in electrical engineering or computer science.

- c. *Environmental Sciences and Engineering*
- i. *Required:* Engineering Sciences 123 plus four half-courses from Earth and Planetary Sciences 133; Engineering Sciences 6, 162, 165, and 168.
  - ii. *Suggested:*  
Earth and Planetary Sciences 107, 108, 109, 132, 133  
Engineering Sciences 6, 103, 139 or 144 (but not both), 162, 165, 167, 168, 261, 262, 268  
Computer Science 246r  
By prior approval, advanced-level MIT courses in environmental sciences and engineering.
- d. *Mechanical and Materials Science and Engineering*
- i. *Required:* Engineering Sciences 120, 123, 125, 181, 190.
  - ii. *Suggested:*  
Applied Mathematics 105a, 105b, 147  
Engineering Sciences 50, 51, 128, 139 or 144 (but not both), 145, 151, 159, 162, 220, 240  
Applied Physics 195  
Physics 123  
Physics 143a or Chemistry 160  
By prior approval, advanced-level MIT courses in mechanics or materials engineering.
7. *Other Information:*
- a. *Pass/Fail:* None of the courses used to satisfy the concentration requirements may be taken Pass/Fail.
  - b. *Plan of Study:* Concentrators are required to file an approved departmental Plan of Study at the end of their freshman year and to keep their plan up-to-date in subsequent years. All SB programs must meet the overall ABET program guidelines, (i.e., a minimum of eight half-courses in basic sciences and mathematics, eight in engineering sciences and four in engineering design). In addition, all programs must include some experimental and computer-based experience. Plan of Study forms may be obtained from the Division of Engineering and Applied Sciences Academic Office, Pierce Hall 110.
  - c. *Additional Terms:* Concentrators who wish to remain a fifth year or a ninth term to complete the SB requirements must be approved to do so by the Committee on Undergraduate Studies in Engineering Sciences. A written petition must be submitted by the end of October of the fall term of the fourth year for approval. Students must also petition the Administrative Board through their Allston Burr Resident Dean. Ordinarily, petitioners are expected to have fulfilled the requirements for an AB program in Engineering Sciences by the end of the fourth year to be eligible to petition for a fifth year or a ninth term.

## ADVISING

Students interested in concentrating in Engineering Sciences should discuss their plans with Mrs. Sandra Godfrey, Academic Programs Administrator; the Director of Undergraduate Studies, or the Assistant Director of Undergraduate Studies. Each undergraduate who elects to concentrate in Engineering Sciences is assigned a faculty adviser depending on his or her area of specialization. The faculty adviser might also be a member of the Committee on Undergraduate Studies in Engineering Sciences, whose members have the responsibility for reviewing departmental Plans of Study. If students do not request a change in adviser, they have the

same adviser until they graduate. Each student is reassigned to another faculty member while his or her original faculty adviser is on leave. It is expected that students will discuss their Plans of Study and progress with their faculty adviser at the beginning of each term. Students may also seek advice from their faculty adviser, the Director of Undergraduate Studies, the Assistant Director of Undergraduate Studies, or the Academic Programs Administrator at any time.

For up-to-date information on advising in Engineering Sciences, please see the Advising Programs Office website: [www.fas.harvard.edu/~advising/concentrations/EngineeringSci.html](http://www.fas.harvard.edu/~advising/concentrations/EngineeringSci.html).

### HOW TO FIND OUT MORE

Further information is available from the Academic Programs Administrator, Mrs. Sandra Godfrey in the School of Engineering and Applied Sciences Academic Office, Pierce Hall 110 (617-495-2833), [godfrey@seas.harvard.edu](mailto:godfrey@seas.harvard.edu), or the Assistant Director of Undergraduate Studies, Dr. Marie Dahleh, Pierce Hall 111 (617-495-1485), [mdahleh@seas.harvard.edu](mailto:mdahleh@seas.harvard.edu). *Undergraduate Teacher Education Program*: Concentrators may be eligible to obtain certification to teach in middle or secondary schools in Massachusetts and the forty-one states with which Massachusetts has reciprocity. See page 47 for more information about the Undergraduate Teacher Education Program (UTEP).

### ENROLLMENT STATISTICS

#### Number of Concentrators as of November

Concentrators	2002	2003	2004	2005	2006
Engineering Sciences	80	38	99	111	106
Engineering Sciences + another field	0	2	1	2	3
Another field + Engineering Sciences	2	1	2	1	1