ELECTRICAL ENGINEERING

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The Electrical Engineering (EE) program at Yale College is designed to equip students with the skills and knowledge needed to thrive in today's rapidly evolving technological landscape. Our undergraduate program broadly encompasses disciplines such as microelectronics, photonics, energy, semiconductor technology, computer engineering, signal and information processing, decision and control systems, and communications. Students engage in hands-on projects and experimental design, honing their ability to analyze complex problems and communicate their findings effectively. Whether pursuing careers in government, industry, or academia, graduates of our program are prepared to make significant contributions to society and address pressing global challenges.

Three electrical engineering degree programs are offered, as well as a joint degree between the electrical engineering and computer science departments.

1. The **B.S. in Electrical Engineering**, accredited by the Engineering Accreditation Commission of ABET, Inc., is the flagship degree program and is the most challenging program in electrical engineering. This program is appropriate for highly motivated students who are interested in entering the engineering profession, and who wish for a flexible enough program to consider a variety of other career paths.

Upon graduation, Yale's B.S. Electrical Engineering (ABET) students are expected to achieve “student outcomes” as defined by ABET and the program. The Electrical Engineering major produces graduates who demonstrate: (1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; (2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors; (3) an ability to communicate effectively with a range of audiences; (4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; (5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives; (6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions; (7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2. The **B.S. in Engineering Sciences (Electrical)** provides similar technical exposure and equivalent rigor as the ABET program, while retaining the flexibility for students to take a broader range of courses than those mandated by the ABET curriculum. The B.S. in Engineering Sciences (Electrical) is suitable for careers in technology and is a popular choice for those choosing academic, industrial, or entrepreneurial career paths.

3. The **B.A. in Engineering Sciences (Electrical)** is suitable for careers outside of technology, including managerial, financial, and entrepreneurial career options.

4. The fourth program is a joint **B.S. in** Electrical Engineering and Computer Science, which offers a unique blend of electrical engineering and computer science courses that retains the rigor of both fields. This degree is a popular choice for those interested in information technology careers.

The program's educational objectives prepare students for four potential paths. An academic path qualifies graduates to enter a top-tier graduate program conducting research with broad applications or significant consequences, and eventually to teach at an academic or research institution. Graduates following an industrial path can enter a technical path or a managerial path. An entrepreneurial path allows graduates to bring broad knowledge to a startup company, which can deliver a product or service that meets societal needs. Graduates who elect a nontraditional engineering path might complete a professional program in business, law, or medicine, for which their engineering knowledge will be valuable.

PREREQUISITES

All three engineering degree programs require MATH 1120 and MATH 1150 if applicable, ENAS 1510 or MATH 1200 or higher, ENAS 1300 (CPSC 1001 does not fulfill this requirement), and PHYS 1800, 1810 or higher (PHYS 1700, 1710 is acceptable for the B.A. degree). Acceleration credits awarded on entrance can be used to satisfy the MATH 1120 and 1150 requirements. Students whose preparation exceeds the level of ENAS 1510 or MATH 1200 are asked to take a higher-level mathematics course instead, such as MATH 2220, MATH 2250, MATH 2260, MATH 2550, or MATH 2560. Similarly, students whose preparation at entrance exceeds the level of PHYS 1800, 1810 are asked to take higher-level physics courses instead, such as PHYS 2000, 2010. Students whose programming skills exceed the level of ENAS 1300 are asked to take a more advanced programming course instead, such as CPSC 2010; consult with the director of undergraduate studies (DUS).

Prerequisites taken Credit/D/Fail may not be counted toward the requirements of the major.

REQUIREMENTS OF THE MAJOR

Because the introductory courses are common to all three degree programs, students do not usually need to make a final degree choice before the junior year. Each student's program must be approved by the DUS.

B.S. degree program in Electrical Engineering The ABET-accredited B.S. in Electrical Engineering requires, beyond the prerequisites, four term courses in mathematics and science and thirteen term courses covering topics in engineering. These courses include:

1. Mathematics and basic science (four term courses): ENAS 1940; MATH 2220 or MATH 2250 or MATH 2260; APHY 3220 or equivalent; S&DS 2380, or S&DS 2410, or equivalent.
2. Electrical engineering and related subjects (thirteen term courses): ECE 2000, 2011, 2020, 2031, 3101, 3200, 3250, 3481, and 4811 (the ABET design project senior requirement); and four engineering electives, at least three of which should be at the 4000 level. CPSC 3650 or CPSC 3660, MENG 3020L,

MENG 2050, MENG 4673, BENG 4611, PHYS 4300, APHY 4580, and all 4000-level computer science courses qualify as ABET electives. One of ECE 4680 or ECE 4691, Advanced Special Projects, also qualify as a 4000-level elective.

The introductory engineering courses are designed such that they may be taken concurrently in the sophomore year; for example, in the fall term students may take ECE 2000 and ECE 2020, followed by ECE 2011 and ECE 2031 in the spring term. These courses may be taken in any order, with the exception of ECE 2031, which requires ECE 2000 as a prerequisite. In this case, it would be helpful to take ENAS 1940 and/or ENAS 1300 in the first year.

A sample ABET-accredited B.S. degree schedule for students who have taken the equivalent of one year of calculus in high school (and thus are not required to take MATH 1120 and MATH 1150) could include:

First Year: ECE 2000, ECE 2011, ENAS 1510, PHYS 1800, and PHYS 1810
Sophomore: ECE 2020, ECE 2031, ENAS 1300, ENAS 1940, and MATH 2220
Junior: ECE 3101, ECE 3200, ECE 3250, ECE 3481, S&DS 2380, and 1 elective
Senior: APHY 3220, ECE 4811, and 3 electives

A sample schedule for students who enter into the ABET-accredited B.S. major at the sophomore year could include:

First Year: ENAS 1510, ENAS 1300, ENAS 1940, PHYS 1800, and PHYS 1810
Sophomore: ECE 2000, ECE 2011, ECE 2020, ECE 2031, and MATH 2220
Junior: ECE 3101, ECE 3200, ECE 3250, ECE 3481, S&DS 2380, and 1 elective
Senior: APHY 3220, ECE 4811, and 3 electives

A sample schedule for students who enter into the ABET-accredited B.S. major in the first year (and are required to take MATH 1120 and MATH 1150) and only seek to fulfill basic distribution requirements with no engineering courses, could be:

First Year: MATH 1120, MATH 1150, PHYS 1800, PHYS 1810, and ENAS 1300
Sophomore: ENAS 1510, ECE 2000, ECE 2011, ECE 2020, ECE 2031, and MATH 2220
Junior: ENAS 1940, ECE 3101, ECE 3200, ECE 3250, ECE 3481, and S&DS 2380
Senior: APHY 3220, ECE 4811, and 4 electives

B.S. degree program in Engineering Sciences (Electrical) This program requires fewer technical courses and allows more freedom for work in technical areas outside the traditional electrical engineering disciplines (e.g., biomedical engineering, mechanical engineering, physics, etc.). It requires thirteen technical term courses beyond the prerequisites, specifically: MATH 2220 or MATH 2250 or MATH 2260; ENAS 1940; ECE 2000, 2011, 2020, 2031; ECE 4710 and/or 4721 (the senior requirement), or with permission of the instructor and the DUS, ECE 4811; and five or six electives (depending on senior requirement) approved by the DUS, at least three of which must be at the 4000 level. All electives listed for the ABET-accredited B.S. major qualify as electives for this degree.

For students who have taken the equivalent of one year of calculus in high school (and thus are not required to take MATH 1120 and MATH 1150), a sample schedule for the B.S. degree in Engineering Science (Electrical) could be:

First Year: ECE 2000, ECE 2000, ENAS 1510, PHYS 1800, and PHYS 1810

Sophomore: ECE 2020, ECE 2031, ENAS 1300, ENAS 1940, and MATH 2220
Junior: 3 electives
Senior: ECE 4710 and/or 4721, and two or three electives depending on the senior project

The B.S. degree in Engineering Sciences (Electrical) requires fewer specific courses and 4 fewer courses overall than the ABET-accredited degree. Any of the courses required for the ABET-accredited major qualify as electives for this degree, as well as other courses with substantial electrical engineering context, subject to the approval of the DUS. For students entering the major during the sophomore year, or those who need introductory calculus in their first year, sample schedules are similar to those described for the ABET-accredited degree program, with the differences in the B.S. Engineering Sciences (Electrical) degree applied.

The flexibility during the junior and senior years in the schedule above is often used to accommodate a second major, such as Economics, Applied Physics, Computer Science, Physics, or Mechanical Engineering.

B.A. degree program in Engineering Sciences (Electrical) This program is appropriate for those planning a career in fields such as business, law, or medicine where scientific and technical knowledge is likely to be useful. It requires eight technical term courses beyond the prerequisites, specifically: MATH 2220, MATH 2250, MATH 2260 or ENAS 1940; ECE 2000, 2011, 2020, and 4710 and/or 4721 (the senior requirement); and two (or three) approved electives.

Credit/D/Fail No courses, including prerequisites, taken Credit/D/Fail may be applied toward the requirements of the major.

Outside credit Courses taken at another institution or during an approved summer or term-time study abroad program may count toward the major requirements with DUS approval.

SENIOR REQUIREMENT

A research or design project carried out in the senior year is required in all three programs and must be approved by the DUS. Students take ECE 4710 and/or 4721, or ECE 4811, present a written report, and make an oral presentation. ECE 4811 is required for students earning the B.S. degree in Electrical Engineering (ABET). Students taking both ECE 4710 and 4721, Senior Advanced Special Projects, may count one as an elective. Arrangements to undertake a project in fulfillment of the senior requirement must be made by the end of the course selection period in the term in which the student will enroll in the course; by this date, a prospectus approved by the intended faculty adviser must be submitted to the DUS.

ADVISING AND APPROVAL OF PROGRAMS

All Electrical Engineering and Engineering Sciences majors must have their programs approved by the DUS. Arrangements to take ECE 4710, 4721, or ECE 4811 are strongly suggested to be made during the term preceding enrollment in the course. Independent research courses (ECE 4680 or ECE 4691) are graded on a Pass/Fail basis, and one (1) can be counted toward the requirements of the major.

SUMMARY OF MAJOR REQUIREMENTS

ELECTRICAL ENGINEERING, B.S.

Prerequisites MATH 1120, 1150 if needed; ENAS 1510 or MATH 1200 or higher; ENAS 1300 or higher; PHYS 1800, 1810 or higher

Number of courses 17 term courses beyond prereqs, incl senior req

Specific courses required ENAS 1940; MATH 2220 or MATH 2250 or MATH 2260; APHY 3220; S&DS 2380 or S&DS 2410; ECE 2000, 2011, 2020, 2031, 3101, 3200, 3250, 3481

Distribution of courses 4 engineering electives, 3 at 4000 level

Senior requirement One-term design project (ECE 4811) with DUS approval

ENGINEERING SCIENCES (ELECTRICAL), B.S. AND B.A.

Prerequisites *Both degrees*—MATH 1120, 1150; ENAS 1510 or MATH 1200 or higher; ENAS 1300 or higher; *B.S.*—PHYS 1800, 1810 or higher; *B.A.*—PHYS 1700, 1710 or higher

Number of courses *B.S.*—13 term courses beyond prereqs, incl senior req; *B.A.*—8 term courses beyond prereqs, incl senior req

Specific courses required *B.S.*—ENAS 1940; MATH 2220 or MATH 2250 or MATH 2260; ECE 2000, 2011, 2020, 2031; *B.A.*—1 from ENAS 1940, MATH 2220, MATH 2250, or MATH 2260; ECE 2000, 2011, 2020

Distribution of courses *B.S.*—5 or 6 electives, depending on senior req, approved by DUS, 3 at 4000 level; *B.A.*—2 or 3 electives, depending on senior req, approved by DUS

Senior requirement *B.S.*—one or two-term research or design project, ECE 4710 and/or 4721, or ECE 4811, approved by DUS; *B.A.* —one or two-term research or design project, ECE 4710 and/or 4721, approved by DUS