**ELECTRICAL ENGINEERING**


The Department of Electrical Engineering (EE) at Stanford innovates by conducting fundamental and applied research to develop physical technologies, hardware and software systems, and information technologies; it educates future academic and industry leaders; and it prepares students for careers in industry, academia, and research labs.

Electrical Engineering has effected societal changes at the heart of the information revolution. All forms of electrical and electronic devices—both hardware and software—are a part of daily lives, whether these are in the home, personal devices, or the infrastructure of communications, information, and computation. Electrical engineers use theories and tools from mathematics and physics to develop systems ranging from smart electric grids, wired and wireless communications and networking, embedded systems, integrated electronics, imaging and sensing devices, to Internet-based information technology.

The Electrical Engineering Department offers the following degrees: Bachelor of Science, Master of Science, and Doctor of Philosophy. The department also offers joint degrees in Electrical Engineering and Law (M.S./J.D.) and Electrical Engineering and Business Administration (M.S./M.B.A.). A minor can be obtained for the Bachelor of Science and Doctor of Philosophy.

**Undergraduate Program in Electrical Engineering**

The mission of the undergraduate program of the Department of Electrical Engineering is to augment the liberal education expected of all Stanford undergraduates, to impart basic understanding of electrical engineering, and to develop skills in the design and building of systems that directly impact societal needs.

The program includes a balanced foundation in the physical sciences, mathematics and computing; core courses in electronics, information systems and digital systems; and develops specific skills in the analysis and design of systems. Students in the major have broad flexibility to select from disciplinary areas beyond the core, including hardware and software, information systems and science, and physical technology and science, as well as electives in multidisciplinary areas, including bioelectronics and bio-imaging, energy and environment and music.

The program prepares students for a broad range of careers—both industrial and government—as well as for professional and academic graduate education.

**Learning Outcomes (Undergraduate)**

The department expects undergraduate majors in the program to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the department’s undergraduate program. The educational objectives of the program are:

1. Technical knowledge—provide a knowledge of electrical engineering principles along with the required supporting knowledge of computing, engineering fundamentals, mathematics, and science. The program must include depth in at least one disciplinary area, currently including hardware and software, information systems and science, and physical technology and science.
2. Laboratory and design skills—develop the basic skills needed to perform and design experimental projects. Develop the ability to formulate problems and projects and to plan a process for solution, taking advantage of diverse technical knowledge and skills.
3. Communications skills—develop the ability to organize and present information and to write and speak effective English.
4. Preparation for further study—provide sufficient breadth and depth for successful subsequent graduate study, postgraduate study, or lifelong learning programs.
5. Preparation for the profession—provide an appreciation for the broad spectrum of issues arising in professional practice, including economics, ethics, leadership, professional organizations, safety, service, and teamwork.

**Graduate Programs in Electrical Engineering**

University regulations governing the M.S. and Ph.D. degrees are described in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin.

The profession of electrical engineering demands a strong foundation in physical science and mathematics, a broad knowledge of engineering techniques, and an understanding of the relationship between technology and society. Curricula at Stanford are planned to offer the breadth of education and depth of training necessary for leadership in the profession. To engage in this profession with competence, four years of undergraduate study and at least one year of postgraduate study are recommended. For those who plan to work in highly technical development or fundamental research, additional graduate study is desirable.

The degree of Master of Science is offered under the general regulations of the University. The master’s program, requiring a minimum of 45 units of graduate study, should be considered by those with the ability and desire to make a life work of professional practice or continued graduate study.

The degree of Doctor of Philosophy is offered under the general regulations of the University. The doctoral program, requiring a minimum of 135 units of graduate study, should be considered by those with the ability and desire to make a life work of research or teaching.

**Learning Outcomes (Graduate)**

The purpose of the master’s program is to provide students with the knowledge and skills necessary for a professional career or doctoral studies. This is done through course work providing specialization in one area of Electrical Engineering and breadth in several other areas. Areas of specialization include Circuits, Software and Hardware Systems, Communications and Networking, Physical Technology and Science, and Signal Processing, Control and Optimization.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research. Through course work and guided research, the program prepares students to make original contributions in Electrical Engineering and related fields.

**Application for Admission**

Applications for graduate admission in Electrical Engineering (EE) should be completed electronically at the Graduate Admissions (http://gradadmissions.stanford.edu) web site. See the Electrical Engineering graduate admissions (http://ee.stanford.edu/admissions) web site for department specific information.
Disciplinary Areas in Electrical Engineering

Electrical Engineering spans a diverse set of intellectual disciplines and applications. The disciplines can be grouped into three overlapping and interrelated areas:

**Hardware/Software Systems**
- Data Science
- Embedded Systems
- Energy-Efficient Hardware Systems
- Integrated Circuits and Power Electronics
- Secure Distributed Systems
- Software Defined Networking
- Mobile Networking

**Information Systems and Science**
- Biomedical Imaging
- Communications Systems
- Control and Optimization
- Data Science
- Information Theory and Applications
- Societal Networks
- Signal Processing and Multimedia

**Physical Technology and Science**
- Biomedical Devices, Sensors and Systems
- Electronic Devices
- Energy Harvesting and Conversion
- Integrated Circuits and Power Electronics
- Nanotechnology and NEMS/MEMS
- Photonics, Nanoscience and Quantum Technology

**Multidisciplinary Research**

EE faculty collaborate with researchers from other departments and schools across campus. While the main applications of electrical engineering in the past four decades have been in information technology, EE tools and techniques are being increasingly applied more broadly to address major societal problems in areas such as:

**Biomedical**
Research in the biomedical area utilizes engineering approaches to meet the unmet needs in diagnosis, staging, treatment, and mitigation of illnesses including cancer, diabetes, heart diseases, as well as brain disorders. Lower-cost, prevention-oriented health care delivery is critically needed, as well as new approaches to previously untreatable health conditions. Addressing these challenges requires discovering and creating fundamentally new devices and systems for critical diagnostics (sensors, imaging), therapeutic (lasers, pacemakers, and neural interfaces), and analytical (high-throughput sequencing, healthcare IT) technologies.

**Energy**
Research in energy is motivated at the macro level by the rapid rise in worldwide demand for electricity and the threat of global climate change and on the micro level by the explosion in the number of mobile devices and sensors whose performance and lifetimes are limited by energy.

For additional information, see the Department of Electrical Engineering’s Research (https://ee.stanford.edu/research/the-big-picture) web site.

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**Electrical Engineering Course Catalog Numbering System**

Electrical Engineering courses are typically numbered according to the year in which the courses are normally taken.

<table>
<thead>
<tr>
<th>Number</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>010-099</td>
<td>first or second year undergraduate</td>
</tr>
<tr>
<td>100-199</td>
<td>second through fourth year undergraduate</td>
</tr>
<tr>
<td>200-299</td>
<td>mezzanine courses for advanced undergraduate or first-year graduate</td>
</tr>
<tr>
<td>300-399</td>
<td>second through fourth year graduate</td>
</tr>
<tr>
<td>400-499</td>
<td>specialized courses for advanced graduate</td>
</tr>
<tr>
<td>600-799</td>
<td>special summer courses</td>
</tr>
</tbody>
</table>

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**Undergraduate Programs in Electrical Engineering**

To major in Electrical Engineering (EE), undergraduates should follow the requirements below. Students must have a program planning sheet approved by their adviser and the department once they declare the EE major. A final version of the completed and signed program sheet is due to the department no later than one month prior to the last quarter of senior year. Program sheets are available at http://ughb.stanford.edu. Students must receive at least a 2.0 grade point average (GPA) in courses taken for the EE major; all classes must be taken for a letter grade.

Students interested in a minor should consult the “Minor in Electrical Engineering (p. 6)” tab of this section of this bulletin.

A Stanford undergraduate may work simultaneously toward the B.S. and M.S. degrees. See the Master's tab (p. 6) of this section of the bulletin.

**Electrical Engineering (EE)**

Completion of the undergraduate program in Electrical Engineering leads to the conferral of the Bachelor of Science in Electrical Engineering.

**Mission of the Undergraduate Program in Electrical Engineering**

The mission of the undergraduate program of the Department of Electrical Engineering is to augment the liberal education expected of all Stanford undergraduates, to impart basic understanding of electrical engineering and to develop skills in the design and building of systems that directly impact societal needs.

The program includes a balanced foundation in the physical sciences, mathematics and computing; core courses in electronics, information systems and digital systems; and develops specific skills in the analysis and design of systems. Students in the major have broad flexibility to select from disciplinary areas beyond the core, including hardware and software, information systems and science, and physical technology and science, as well as electives in multidisciplinary areas, including bioelectronics and bio-imaging, energy and environment and music.

The program prepares students for a broad range of careers—both industrial and government—as well as for professional and academic graduate education.
Requirements

Mathematics ¹

Select one sequence: May also be satisfied with AP Calculus. ¹

MATH 19 Calculus
& MATH 20 and Calculus
& MATH 21 and Calculus

Select one 2-course sequence: ¹

CME 100 & CME 102 Vector Calculus for Engineers
and Ordinary Differential Equations for Engineers (Same as ENGR 154 and ENGR 155A)

MATH 51 & MATH 53 Linear Algebra, Multivariable Calculus, and
Modern Applications and Ordinary Differential Equations with
Linear Algebra ²

EE Math. One additional 100-level course. Select one: ²

EE 103 Introduction to Matrix Methods (Preferred) ¹

MATH 113 Linear Algebra and Matrix Theory
CS 103 Mathematical Foundations of Computing
Statistics/Probability. Select one: ²

EE 178 Probabilistic Systems Analysis (Preferred)
CS 109 Introduction to Probability for Computer Scientists

Science ³

Minimum 12 units

Select one sequence: ¹

PHYSICS 41 Mechanics and Introduction to Electromagnetics and
Its Applications ³

PHYSICS 41 & PHYSICS 43 Mechanics and Electricity and Magnetism ³

PHYSICS 61 & PHYSICS 63 Mechanics and Special Relativity
and Electricity, Magnetism, and Waves

Science elective. One additional 4-5 unit course from approved
list in Undergraduate Handbook, Figure 4-2. ⁴

Technology in Society

One course, see Basic Requirement 4 in the School of Engineering
section. The course taken must be on the School of Engineering
Approved Courses list, Fig 4-3, the year it is taken.

Engineering Topics

Minimum 60 units comprised of: Engineering Fundamentals
(minimum 10 units), Core Electrical Engineering Courses
(minimum 16 units) Disciplinary Area (minimum 17 units),
Electives (maximum 17 units, restrictions apply).

Engineering Fundamentals

2 courses required; minimum 10 units

Select one:

CS 106B/ENGR 70B Programming Abstractions
or CS 106X/ENGR 70X Programming Abstractions (Accelerated)

Choose one Fundamental from the Approved List; ⁵

Recommended: ENGR 40A and ENGR 40B or ENGR 40M
(recommended before taking EE 101A); taking CS 106A or a
second ENGR 40-series course not allowed for the Fundamentals
elective. Choose from table in Undergraduate Handbook,
Approved List.

Core Electrical Engineering Courses

EE 100 The Electrical Engineering Profession ⁴
EE 101A Circuits I
EE 102A Signal Processing and Linear Systems I
EE 108 Digital System Design
Physics of Electrical Engineering.
EE 65 Modern Physics for Engineers ⁵

Disciplinary Area

Minimum 17 units; 5 courses: 1-2 Required, 1 WIM/Design and 2-3
disciplinary area electives.

Writing in the Major (WIM)

Select one. A single course can concurrently meet the WIM and
Design Requirements.

EE 109 Digital Systems Design Lab (WIM/Design)
EE 133 Analog Communications Design Laboratory
(WIM/Design)
EE 134 Introduction to Photonics (WIM/Design)
EE 153 Power Electronics (WIM/Design)
EE 155 Green Electronics (WIM/Design)
EE 168 Introduction to Digital Image Processing
(WIM/Design)
EE 191W Special Studies and Reports in Electrical
Engineering (WIM; Department approval
required) ⁶
EE 264W Digital Signal Processing (WIM/Design)
EE 267W Virtual Reality (WIM/Design)
CS 194W Software Project (WIM/Design)

Design Course ³

Select one. Students may select their Design course from any
Disciplinary Area.

EE 109 Digital Systems Design Lab (WIM/Design)
EE 133 Analog Communications Design Laboratory
(WIM/Design)
EE 134 Introduction to Photonics (WIM/Design)
EE 153 Power Electronics (WIM/Design)
EE 155 Green Electronics (WIM/Design)
EE 168 Introduction to Digital Image Processing
(WIM/Design)
EE 262 Two-Dimensional Imaging (Design)
EE 264 Digital Signal Processing (Design) ⁷
EE 264W Digital Signal Processing (WIM/Design)
EE 267 Virtual Reality (Design) ⁷
EE 267W Virtual Reality (WIM/Design)
CS 194 Software Project (Design)
CS 194W Software Project (WIM/Design)

Electives ¹

Minimum 17 units. The elective units should be sufficient to
meet the 60 unit total for the major, over and above the 40 units
of Math and Science. Depending on units completed in the
Disciplinary Area, elective units will be in the range of 17 units or
less. Students may select electives from the disciplinary areas;
from the multidisciplinary elective areas; or any combination
of disciplinary and multidisciplinary areas. May include up to
Two additional Engineering Fundamentals, any CS 193 course
and any letter graded EE courses (minus any previously noted
restrictions). Freshman and Sophomore seminars, EE 191 and
CS 190A do not count toward the 60 units. Students may have
fewer elective units if they have more units in their disciplinary
area.

¹ Math 41 and Math 42 are no longer offered and have been replaced
by MATH 19, MATH 20, and MATH 21. If used for math, EE 103 may
not be used as an EE disciplinary elective. PHYSICS 41E may be used
in place of PHYSICS 41.
MATH 52 may be taken in place of MATH 51. CME 102 can be taken in place of MATH 53.

EE 42 may be used in place of PHYSICS 43 (if not used in EE electives area). The EE introductory class ENGR 40A and ENGR 40B or ENGR 40M may be taken concurrently with either EE 42 or PHYSICS 43. There are no prerequisites for ENGR 40A and ENGR 40B or ENGR 40M.

For upper division students, a 200-level seminar in their disciplinary area will be accepted, on petition.

Students may petition to have either PHYSICS 65 or the combination of PHYSICS 45 and PHYSICS 70 count as an alternative to EE 65.

EE 191W may satisfy WIM only if it is a follow-up to an REU, independent study project or as part of an honors thesis project where a faculty agrees to provide supervision of writing a technical paper and with suitable support from the Writing Center.

A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken with suitable support from the Writing Center.

To satisfy Design, must take EE 264 or EE 267 for 4 units and complete the laboratory project.

A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Fundamentals and Depth is 2.0.

### Disciplinary Areas

#### Hardware and Software

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 103</td>
<td>Introduction to Matrix Methods</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 104</td>
<td>Introduction to Machine Learning</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 180</td>
<td>Digital Systems Architecture (Required)</td>
<td>4</td>
</tr>
<tr>
<td>EE 107</td>
<td>Embedded Networked Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 109</td>
<td>Digital Systems Design Lab (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 118</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics (Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 264</td>
<td>Digital Signal Processing (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 264W</td>
<td>Digital Signal Processing (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 267</td>
<td>Virtual Reality (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 267W</td>
<td>Virtual Reality (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 271</td>
<td>Introduction to VLSI Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 272</td>
<td>Design Projects in VLSI Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 273</td>
<td>Digital Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 282</td>
<td>Computer Systems Architecture</td>
<td>3</td>
</tr>
<tr>
<td>EE 285</td>
<td>Embedded Systems Workshop</td>
<td>2</td>
</tr>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems (Required)</td>
<td>3-5</td>
</tr>
<tr>
<td>or CS 107E</td>
<td>Computer Systems from the Ground Up</td>
<td></td>
</tr>
<tr>
<td>CS 108</td>
<td>Object-Oriented Systems Design</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 110</td>
<td>Principles of Computer Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 131</td>
<td>Computer Vision: Foundations and Applications</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 140</td>
<td>Operating Systems and Systems Programming</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 143</td>
<td>Compilers</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 144</td>
<td>Introduction to Computer Networking</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 145</td>
<td>Data Management and Data Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 148</td>
<td>Introduction to Computer Graphics and Imaging</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 149</td>
<td>Parallel Computing</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 155</td>
<td>Computer and Network Security</td>
<td>3</td>
</tr>
<tr>
<td>CS 194W</td>
<td>Software Project (WIM/Design)</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Information Systems and Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 102B</td>
<td>Signal Processing and Linear Systems II (Required)</td>
<td>4</td>
</tr>
<tr>
<td>EE 103</td>
<td>Introduction to Matrix Methods</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 104</td>
<td>Introduction to Machine Learning</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 107</td>
<td>Embedded Networked Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 118</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>EE 124</td>
<td>Introduction to Neuroelectrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 133</td>
<td>Analog Communications Design Laboratory (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 168</td>
<td>Introduction to Digital Image Processing (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 169</td>
<td>Introduction to Bioimaging</td>
<td>3</td>
</tr>
<tr>
<td>EE 179</td>
<td>Analog and Digital Communication Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 261</td>
<td>The Fourier Transform and Its Applications</td>
<td>3</td>
</tr>
<tr>
<td>EE 262</td>
<td>Two-Dimensional Imaging (Design)</td>
<td>3</td>
</tr>
<tr>
<td>EE 263</td>
<td>Introduction to Linear Dynamical Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 264</td>
<td>Digital Signal Processing (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 264W</td>
<td>Digital Signal Processing (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 267</td>
<td>Virtual Reality (Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 267W</td>
<td>Virtual Reality (WIM/Design)</td>
<td>5</td>
</tr>
<tr>
<td>EE 278</td>
<td>Introduction to Statistical Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EE 279</td>
<td>Introduction to Digital Communication</td>
<td>3</td>
</tr>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>ENGR 105</td>
<td>Feedback Control Design</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 205</td>
<td>Introduction to Control Design Techniques</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Physical Technology and Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 101B</td>
<td>Circuits II (Required)</td>
<td>4</td>
</tr>
<tr>
<td>EE 103</td>
<td>Introduction to Matrix Methods</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 107</td>
<td>Embedded Networked Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 114</td>
<td>Fundamentals of Analog Integrated Circuit Design</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 116</td>
<td>Semiconductor Devices for Energy and Electronics</td>
<td>3</td>
</tr>
<tr>
<td>EE 118</td>
<td>Introduction to Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>EE 124</td>
<td>Introduction to Neuroelectrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 133</td>
<td>Analog Communications Design Laboratory (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 134</td>
<td>Introduction to Photonics (WIM/Design)</td>
<td>4</td>
</tr>
<tr>
<td>EE 142</td>
<td>Engineering Electromagnetics</td>
<td>3</td>
</tr>
<tr>
<td>EE 153</td>
<td>Power Electronics (WIM/Design)</td>
<td>3-4</td>
</tr>
<tr>
<td>EE 155</td>
<td>Green Electronics (WIM/Design)</td>
<td>4</td>
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</tbody>
</table>
Multidisciplinary Area Electives

CEE 176B
CEE 176A
CEE 155
CEE 107A
EE 293B
EE 263
EE 180
EE 168
EE 155
EE 153
EE 151
EE 134
EE 116
EE 101B
Energy and Environment

EE 264
EE 264W
EE 267
EE 267W
EE 271
EE 272
EE 273
EE 282
CS 107
ENGR 105

Music

EE 102B
EE 109
EE 264
EE 264W
MUSIC 250A
MUSIC 256A
MUSIC 256B
MUSIC 257
MUSIC 320
MUSIC 420A
MUSIC 421A
MUSIC 422
MUSIC 424

EE 264W
EE 264
EE 102B
EE 109
EE 264
EE 264W

MUSIC 422
MUSIC 424

Energy and Environment

EE 101B
EE 103
EE 116
EE 134
EE 151
EE 153
EE 155
EE 168
EE 180
EE 263
EE 293
EE 293B
CEE 107A
CEE 155
CEE 176A
CEE 176B

ENGR 105
ENGR 205
MATSCI 142
MATSCI 152
MATSCI 156
ME 185
ME 227
ME 271E

Biodesign Fundamentals

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6. Attend poster and oral presentation held at the end of spring quarter or present in another suitable forum approved by the faculty adviser.

**Electrical Engineering (EE) Minor**
The options for completing a minor in EE are outlined below. Students must complete a minimum of 23-25 units, as follows:

<table>
<thead>
<tr>
<th>Select one:</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 42 Introduction to Electromagnetics and Its Applications</td>
<td>5</td>
</tr>
<tr>
<td>EE 65 Modern Physics for Engineers</td>
<td></td>
</tr>
<tr>
<td>ENGR 40A Introductory Electronics &amp; ENGR 40B and Introductory Electronics Part II</td>
<td></td>
</tr>
<tr>
<td>ENGR 40M An Intro to Making: What is EE</td>
<td></td>
</tr>
</tbody>
</table>

**Option I:**
- EE 101A Circuits I
- EE 101B Circuits II

**Option II:**
- EE 102A Signal Processing and Linear Systems I
- EE 102B Signal Processing and Linear Systems II

**Option III:**
- EE 102A Signal Processing and Linear Systems I
- EE 103 Introduction to Matrix Methods

**Option IV:**
- EE 108 Digital System Design
- EE 180 Digital Systems Architecture

In addition, four letter-graded EE courses at the 100-level or higher must be taken (12 units minimum). CS 107 is required as a prerequisite for EE 180, but can count as one of the four classes.

**Master of Science in Electrical Engineering**
Students with undergraduate degrees in physics, mathematics, or related sciences, as well as in various branches of engineering, are invited to apply for admission. They should typically be able to complete the master’s degree in five quarters; note that many courses are not taught during the summer. Capable students without formal undergraduate preparation in electrical engineering may also be admitted for graduate study. Such students may have graduated in any field and may hold either the B.S. or B.A. degree. Graduate study in electrical engineering demands preparation in electrical engineering. The student and principal adviser must also identify another faculty member, who need not be in the Department of Electrical Engineering, to serve as a secondary adviser and reader for the research work. The research adviser must be a member of the Academic Council and must hold an appointment in Electrical Engineering.

A student who wishes to pursue the M.S. in EE with distinction in research must first identify a faculty adviser who agrees to supervise and support the research work. The research adviser must be a member of the Academic Council and must hold an appointment in Electrical Engineering. The student and principal adviser must also identify another faculty member, who need not be in the Department of Electrical Engineering, to serve as a secondary adviser and reader for the research report. In addition, the student must complete the following requirements beyond those for the regular M.S. in EE degree:

1. **Research Experience**—The program must include significant research experience at the level of a half-time commitment over the course of three academic quarters. In any given quarter, the half-time research commitment may be satisfied by:
   - a 50 percent appointment to a departmentally supported research assistantship,
   - 6 units of independent study (EE 300 or EE 391)
   - a prorated combination of the two (such as a 25 percent research assistantship supplemented by 3 units of independent study).
   - An equivalent research experience while fully supported on a Stanford-funded or externally funded fellowship. Student and research adviser must document the planned research experience before the quarter starts and its completion at the end. Note: Fellowship must provide full support at the 10-unit tuition level, and allow the student to pursue degree-related research in addition to his/her fulltime course enrollment. This research must be carried out under the direction of the primary or secondary adviser.
2. **Supervised Writing and Research**—In addition to the research experience outlined in the previous requirement, students must...
enroll in at least 3 units of independent research (EE 300 or EE 391) under the direction of their primary or secondary adviser. These units should be closely related to the research described in the first requirement, but focused more directly on the preparation of the research report described in the next section. The writing and research units described in parts (1) and (2) may be counted toward the 45 units required for the degree.

3. All independent study units (EE 300 or EE 391) must be taken for letter grades and a GPA of 3.0 (B) or better must be maintained.

4. Research Report—Students must complete a significant report describing their research and its conclusions. The research report represents work that is publishable in a journal or at a high-quality conference, although it is presumably longer and more expansive in scope than a typical conference paper. A copy of the research report must be submitted to the student services office in the department three weeks before the beginning of the examination period in the student’s final quarter. Both the primary and secondary adviser must approve the research report before the distinction-in-research designation can be conferred.

The Honors Cooperative Program

Many of the department’s graduate students are supported by the Honors Cooperative Program (HCP), which makes it possible for academically qualified engineers and scientists in nearby companies to be part-time master’s students in Electrical Engineering while continuing nearly full-time professional employment. Prospective HCP students follow the same admission process and must meet the same admission requirements as full-time master’s students. For more information regarding the Honors Cooperative Program, see the “School of Engineering” section of this bulletin.

Joint Electrical Engineering and Law Degree (M.S./J.D.)

The Department of Electrical Engineering and the School of Law offer a joint degree program leading to an M.S. degree in EE combined with a J.D. degree. The J.D./M.S. program is designed for students who wish to prepare themselves for careers that involve both Law and Electrical Engineering.

Students interested in this joint degree program must apply to and gain admission separately from the Department of Electrical Engineering and the School of Law, and as an additional step, secure consent from both academic units to pursue both degrees simultaneously. Interest in the program should be noted on a student’s application to each academic unit. A student currently enrolled in either the Department of Electrical Engineering or the School of Law may apply for admission to the other academic unit and for joint degree status after commencing study in that unit.

Joint Electrical Engineering and Master’s in Business Administration Degree (M.S./M.B.A.)

The Department of Electrical Engineering and the Graduate School of Business offer a joint degree program leading to an M.S. degree in EE combined with an M.B.A. degree. The joint program offers students an opportunity to develop advanced technical and managerial skills in preparation for careers in existing and new technology ventures.

Admission to the joint M.S./M.B.A. program requires that students apply and be accepted independently to both the Electrical Engineering Department at the School of Engineering and the Graduate School of Business. Students may apply concurrently, or elect to begin their course of study in EE and apply to the GSB during their first year.

See the EE Graduate Handbook (https://stanford.box.com/s/dhub14fllfcjupj49zn1k9b8py57197bp) for more information about the joint degree programs.

Doctor of Philosophy in Electrical Engineering

The University requirements for the Ph.D. degree are described in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin.

Admission to a graduate program does not imply that the student is a candidate for the Ph.D. degree. Advancement to candidacy requires superior academic achievement, satisfactory performance on a qualifying examination, and sponsorship by two faculty members. Enrollment in EE 391, Special Studies, is recommended as a means for getting acquainted with a faculty member who might be willing to serve as the dissertation advisor.

Students admitted to the Ph.D. program must sign up to take the department qualifying examination (https://ee.stanford.edu/academics/graduate-degree-progress/quals). Students are required to pass the qualifying exam prior to the end of winter quarter of their second year of study. Students who have never taken the qualifying examination or have not passed the qualifying exam will be dismissed from the Ph.D. program for failure to progress. Such students may be allowed to complete a master’s degree in Electrical Engineering instead.

Upon completion of the qualifying examination and after securing agreement by two faculty members to serve as dissertation adviser and second reader, the student files an Application for Candidacy for Doctoral Degree. The dissertation adviser must be a member of the Academic Council. One of the two faculty members must either have a full or joint appointment in the Electrical Engineering department. Students are required to advance to candidacy prior to the end of their second year in the graduate program. Students who do not advance to candidacy by the end of their second year will be dismissed from the Ph.D. program for failure to progress. Such students may be allowed to complete a master’s degree in Electrical Engineering instead.

Only after receiving department approval of the Application for Candidacy does the student become a candidate for the Ph.D. degree.

For complete requirements and additional information, see the department’s web site (https://ee.stanford.edu/academics/graduate-degree-progress).

Financial Assistance

The department awards a limited number of fellowships, teaching and course assistantships, and research assistantships to incoming graduate students. Applying for financial assistance is part of the admission application.

Ph.D. Minor in Electrical Engineering

For a minor in Electrical Engineering, students must fulfill the M.S. degree depth requirement, complete at least 20 units of lecture course work at the 200-level or higher in Electrical Engineering courses (of which 15 units must be letter-graded), and have the Application for Ph.D. Minor approved by the EE department and the major department. A grade point average of at least 3.35 on these courses is required.

Graduate Advising Expectations

The Department of Electrical Engineering is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations
should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising" section of this bulletin.


Chair: Stephen Boyd

Associate Chairs: Robert W. Dutton (Undergraduate Education), Fouad Tobagi (Graduate Education), Howard Zebker (Admissions)

Academic Affairs Committee Chair: Joseph M. Kahn


Associate Professors: Dawson Engler, Sachin Katti, Philip Levis, Ada Poon, Eric Pop

Assistant Professors: Amin Arbabian, John Duchi, Jonathan Fan, Ayfer Ozgur Aydin, Mert Pilanci, Priyanka Raina, Juan Rivas, Dorsa Sadigh, Gordon Wetzstein, Mary Wootters

Professors (Research): William J. Dally, Butrus Khuri-Yakub, Piero Pianetta


Courteous Associate Professors: Mohsen Bayati, Sigrid Close, Ramesh Johari, Jin Hyung Lee, Ram Rajagopal, Amin Saberi

Lecturers: Dennis Allison, Raul Camposano, Jonathan Candelaria, Andrea Di Blas, Antun Domic, Abbas Emami-Naeini, Leslie Field, J. Andrew Freeman, Timothy Gould, Patrick Groenewald, My T. Ho, Scott Murray, David Obershaw, Dan O’Neill, Ronald Quan, Jatinder Singh, Jason Stinson, James Weaver

Adjunct Professors: Ahmad Bahai, Rick Bahr, David Bloom, Fred M. Gibbons, Dimitry Gorinevsky, Bob S. Hu, Theodore Kamins, Fred Kish, David Leeson, Georgios Michelogiannakis, Fernando Mujica, Reza Nasiri Mahalati, Stephen Ryu, Ronald Schafer, Ashok Srivastava, David Sussillo, John Wenstrand, Sebastian Thrun

Visiting Professor: Wei-Zen Chen

Visiting Associate Professor: Matthew Gilbert

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