Electrical Engineering

Undergraduate Study

For the undergraduate curriculum in electrical engineering leading to the degree Bachelor of Science. This curriculum is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

The Department of Electrical and Computer Engineering (ECpE) at Iowa State University provides undergraduate students with the opportunity to learn electrical and computer engineering fundamentals, study applications of the most recent advances in state-of-the-art technologies, and prepare for the practice of electrical engineering. The student-faculty interaction necessary to realize this opportunity occurs within an environment that is motivated by the principle that excellence in undergraduate education is enhanced by an integrated commitment to successful, long-term research and outreach programs.

The electrical engineering curriculum offers a number of emphasis areas at the undergraduate level, including control systems, electromagnetics and nondestructive evaluation, microelectronics and photonics, VLSI, electric power and energy systems, and communications and signal processing. Students are required to choose at least one course sequence that focuses on one of these areas; therefore graduates have substantial depth in specific areas to complement the breadth obtained in the required curriculum. Students also may take elective courses in computer networking, security, computer architecture, digital systems, and software.

The program objectives for the electrical engineering program describe accomplishments that graduates are expected to attain within five years after graduation. Graduates will have applied their expertise to contemporary problem solving, be engaged professionally, have continued to learn and adapt, and have contributed to their organizations through leadership and teamwork. More specifically, the objectives for expertise, engagement, learning, leadership and teamwork are defined below for each program.

The objective of the electrical engineering program at ISU are:

• Graduates, within five years of graduation, should demonstrate peer-recognized expertise together with the ability to articulate that expertise and use it for contemporary problem solving in the analysis, design, and evaluation of electrical and electronic devices and systems.
• Graduates, within five years of graduation, should demonstrate engagement in the engineering profession, locally and globally, by contributing to the ethical, competent, and creative practice of engineering or other professional careers.
• Graduates, within five years of graduation, should demonstrate sustained learning and adapting to a constantly changing field through graduate work, professional development, and self study.
• Graduates, within five years of graduation, should demonstrate leadership and initiative to ethically advance professional and organizational goals, facilitate the achievements of others, and obtain substantive results.
• Graduates, within five years of graduation, should demonstrate a commitment to teamwork while working with others of diverse cultural and interdisciplinary backgrounds.

As a complement to the instructional activity, the ECpE department provides opportunities for each student to have experience with broadening activities. Through the cooperative education and internship program, students have the opportunity to gain practical industry experience.

Students have the opportunity to participate in advanced research activities, and through international exchange programs, students learn about engineering practices in other parts of the world. Well-qualified juniors and seniors in electrical engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue both the Bachelor of Science and Master of Science degrees in bioinformatics and computational biology. Students interested in these programs may earn their degrees while working under an adviser in electrical and computer engineering.

Well-qualified juniors or seniors in electrical engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue both the Bachelor of Science and Master of Science degrees, the Bachelor of Science and Master of Business Administration, or the Bachelor of Science and Master of Engineering degrees. Under concurrent enrollment, students are eligible for assistantships and simultaneously take undergraduate and graduate courses. Details are available in the Student Services Office and on the department’s website.

Curriculum in Electrical Engineering

Administered by the Department of Electrical and Computer Engineering. Leading to the degree Bachelor of Science.

Total credits required: 128 See also Basic Program and Special Programs.

International Perspectives: 3 cr. ¹

U.S. Diversity: 3 cr. ¹

Communication Proficiency/Library requirement:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ENGL 150</td>
<td>Critical Thinking and Communication *</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 250</td>
<td>Written, Oral, Visual, and Electronic Composition *</td>
<td>3</td>
</tr>
<tr>
<td>LIB 160</td>
<td>Information Literacy</td>
<td>1</td>
</tr>
</tbody>
</table>

Graduate Study

The department offers work for the degrees Master of Engineering, Master of Science, and Doctor of Philosophy with a major in electrical engineering and minor work to students with other majors. Minor work for electrical engineering majors is usually selected from a wide range of courses outside electrical engineering.

Master of Engineering degree is coursework only. It is recommended for off-campus students.

The degree Master of Science with thesis is recommended for students who intend to continue toward the Doctor of Philosophy degree or to undertake a career in research and development. The non-thesis Master of Science degree requires a creative component.

The department also offers a graduate certificate program in power systems engineering. Completion of the certificate requires at least 12 credits selected from:

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>E E 553</td>
<td>Steady State Analysis</td>
<td>3</td>
</tr>
<tr>
<td>E E 554</td>
<td>Power System Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>E E 555</td>
<td>Advanced Energy Distribution Systems</td>
<td>3</td>
</tr>
<tr>
<td>E E 556</td>
<td>Power Electronic Systems</td>
<td>3</td>
</tr>
<tr>
<td>E E 653</td>
<td>Advanced Topics in Electric Power System Engineering</td>
<td>3</td>
</tr>
<tr>
<td>E E 653</td>
<td>Advanced Topics in Electric Power System Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

Students interested in this program should see the Complex Adaptive Systems section of the catalog for requirements.

The Department of Electrical and Computer Engineering is a participating department in the interdepartmental graduate minor in complex adaptive systems. Students interested in this program should see the Complex Adaptive Systems section of the catalog for requirements.

The Department of Electrical and Computer Engineering is a participating department in the interdepartmental Master of Science and Doctor of Philosophy degree programs in biotechnology and computational biology. Students interested in these programs may earn their degrees while working under an adviser in electrical and computer engineering.

Well-qualified juniors or seniors in electrical engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue both the Bachelor of Science and Master of Science degrees, the Bachelor of Science and Master of Business Administration, or the Bachelor of Science and Master of Engineering degrees. Under concurrent enrollment, students are eligible for assistantships and simultaneously take undergraduate and graduate courses. Details are available in the Student Services Office and on the department’s website.
**Electrical Engineering**

<table>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ENGL 314</td>
<td>Technical Communication</td>
<td>3</td>
</tr>
<tr>
<td>or ENGL 309</td>
<td>Report and Proposal Writing</td>
<td></td>
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</table>

* minimum grade of C

**General Education Electives:** 15 cr.

**Basic Program:** 27 cr.

Complete with 2.00 GPA including transfer courses (see above for grade requirements):

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHEM 167</td>
<td>General Chemistry for Engineering Students</td>
<td>4</td>
</tr>
<tr>
<td>or CHEM 177</td>
<td>General Chemistry I</td>
<td></td>
</tr>
<tr>
<td>ENG 150</td>
<td>Critical Thinking and Communication</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 250</td>
<td>Written, Oral, Visual, and Electronic Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 101</td>
<td>Engineering Orientation</td>
<td>R</td>
</tr>
<tr>
<td>E E 185</td>
<td>Introduction to Electrical Engineering and Problem-Solving</td>
<td>3</td>
</tr>
<tr>
<td>LIB 160</td>
<td>Information Literacy</td>
<td>1</td>
</tr>
<tr>
<td>MATH 165</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 166</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 221</td>
<td>Introduction to Classical Physics I (See Basic Program rule)</td>
<td>5</td>
</tr>
</tbody>
</table>

Total Credits: 27

**Math and Physical Science:** 16 cr.

<table>
<thead>
<tr>
<th>Course Code</th>
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</thead>
<tbody>
<tr>
<td>MATH 265</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 267</td>
<td>Elementary Differential Equations and Laplace Transforms</td>
<td>4</td>
</tr>
<tr>
<td>MATH 207</td>
<td>Matrices and Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 222</td>
<td>Introduction to Classical Physics II</td>
<td>5</td>
</tr>
</tbody>
</table>

Total Credits: 16

**Electrical Engineering Core:** 41 cr.

<table>
<thead>
<tr>
<th>Course Code</th>
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</thead>
<tbody>
<tr>
<td>E E 285</td>
<td>Problem Solving Methods and Tools for Electrical Engineering</td>
<td>4</td>
</tr>
<tr>
<td>CPR E 281</td>
<td>Digital Logic</td>
<td>4</td>
</tr>
<tr>
<td>CPR E 288</td>
<td>Embedded Systems I: Introduction</td>
<td>4</td>
</tr>
<tr>
<td>E E 201</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>E E 230</td>
<td>Electronic Circuits and Systems</td>
<td>4</td>
</tr>
<tr>
<td>E E 224</td>
<td>Signals and Systems I</td>
<td>4</td>
</tr>
<tr>
<td>E E 303</td>
<td>Energy Systems and Power Electronics</td>
<td>3</td>
</tr>
<tr>
<td>E E 311</td>
<td>Electromagnetic Fields and Waves</td>
<td>4</td>
</tr>
<tr>
<td>E E 322</td>
<td>Probabilistic Methods for Electrical Engineers</td>
<td>3</td>
</tr>
<tr>
<td>E E 330</td>
<td>Integrated Electronics</td>
<td>4</td>
</tr>
<tr>
<td>E E 332</td>
<td>Semiconductor Materials and Devices</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits: 41

**Other Remaining Courses:** 29 cr.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>E E 491</td>
<td>Senior Design Project I and Professionalism</td>
<td>3</td>
</tr>
<tr>
<td>E E 492</td>
<td>Senior Design Project II</td>
<td>2</td>
</tr>
<tr>
<td>I E 305</td>
<td>Engineering Economic Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 309</td>
<td>Report and Proposal Writing</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 314</td>
<td>Technical Communication</td>
<td></td>
</tr>
<tr>
<td>E E/Cpr E</td>
<td>Technical Electives including one approved sequence</td>
<td>5</td>
</tr>
<tr>
<td>Elective from Math, E E, Cpr E and/or non-E E/Cpr E</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Total Credits: 29

* minimum grade of C

**Seminar/Co-op/Internships:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E E 166</td>
<td>Professional Programs Orientation</td>
<td>R</td>
</tr>
<tr>
<td>E E 294</td>
<td>Program Discovery</td>
<td>R</td>
</tr>
<tr>
<td>E E 394</td>
<td>Program Exploration</td>
<td>R</td>
</tr>
</tbody>
</table>

**Co-op or Internship is optional**

**Outcomes Assessment**

- Students are required to prepare and to maintain a portfolio of their technical and non-technical skills. This portfolio is evaluated for student preparation during the student’s curriculum planning process. Results of the evaluation are used to advise students of core strengths and weaknesses.

**Transfer Credit Requirements**

The degree program must include a minimum of 30 credits at the 300-level or above in professional and technical courses earned at ISU in order to receive a B.S. in electrical engineering. These 30 credits must include E E 491 Senior Design Project I and Professionalism, E E 492 Senior Design Project II, and credits in the core professional curriculum and/or in technical electives. The Electrical and Computer Engineering Department requires a grade of C or better for any transfer credit course that is applied to the degree program.

1. These university requirements will add to the minimum credits of the program unless the university-approved courses are also approved by the department to meet other course requirements within the degree program. U.S. diversity and international perspectives courses may not be taken Pass/Not Pass.
2. Complete minimum of 6 cr. from Approved General Education Component at 300 or higher level. Complete additional 9 cr. from Approved General Education Component.
3. See Basic Program for Professional Engineering Curricula for accepted substitutions for curriculum designated courses in the Basic Program.
4. 2.00 required including transfer courses.
5. From department approved lists

See also: A 4-year plan of study grid showing course template by semester.

Note: International perspectives and U.S. diversity courses are used to meet the general education electives.

**Courses primarily for undergraduates:**

**E E 166. Professional Programs Orientation.**

(Cross-listed with CPR E). Cr. R. F.S.

(1-0) Overview of the nature and scope of electrical engineering and computer engineering careers. Overview of portfolios. Departmental rules, advising center operations, degree requirements, program of study planning, career options, and student organizations.

**E E 185. Introduction to Electrical Engineering and Problem-Solving I.**

(2-2) Cr. 3. F.S. Prereq: Credit or enrollment in MATH 142


**E E 186. Introduction to Electrical Engineering and Problem Solving II.**

(0-2) Cr. 1. S. Prereq: E E 185

Project based and hands on continuation of 185. Group skills needed to work effectively in teams. Individual interactive skills for small and large groups. Learning to use tools and methods for solving electrical engineering problems.

**E E 188. Bio-Electrical Engineering Fundamentals Laboratory.**

(1-3) Cr. 2. Prereq: E E 185 or equivalent

Fundamental laboratory based course in bio-electrical engineering with an emphasis on acquiring and analyzing biomedical signals to obtain relevant information. Topics covered include an overview of basic medical terminology and anatomy, labs illustrating data acquisition from different body systems, and an introduction to statistical significance and its relationship to biological variability.

**E E 201. Electric Circuits.**

(3-2) Cr. 4. S. Prereq: Credit or registration in MATH 267 and PHYS 222

Emphasis on mathematical tools. Circuit elements (resistors, inductors, capacitors) and analysis methods including power and energy relationships. Network theorems. DC, sinusoidal steady-state, and transient analysis. AC power. Frequency response. Two port models. Diodes, DSPICE. Laboratory instrumentation and experimentation. Credit for only E E 201 or 442 may be used towards graduation.
E E 224. Signals and Systems I.  
(3-3) Cr. 4. F,S. Prereq: E E 201, MATH 267, PHYS 222  

(3-3) Cr. 4. F,S. Prereq: E E 201, MATH 267, PHYS 222  

E E 261. Transfer Orientation.  
(Cross-listed with CPR E). Cr. R.  
Introduction to the College of Engineering and the engineering profession specifically for transfer students. Information concerning university and college policies, procedures, and resources. Offered on a satisfactory-fail basis only.

(3-3) Cr. 4.  

E E 294. Program Discovery.  
(Cross-listed with CPR E). Cr. R. Prereq: CPR E 166 or E E 166  
The roles of professionals in computer and electrical engineering. Relationship of coursework to industry and academic careers. Issues relevant to today’s world. Offered on a satisfactory-fail basis only.

E E 298. Cooperative Education.  
Cr. R. F.S.SS. Prereq: Permission of department and Engineering Career Services  
First professional work period in the cooperative education program. Students must register for this course before commencing work.

(3-0) Cr. 3. F,S. Prereq: MATH 267, Phys 222. Credit or registration in E E 224 and E E 230  

(4-0) Cr. 4. F,S. Prereq: E E 201, MATH 265, PHYS 222, credit or registration in MATH 267  

E E 314. Electromagnetics for non Electrical Engineers.  
(3-0) Cr. 3. Prereq: PHYS 222, PHYS 112, or equivalent  
Conceptual study of electromagnetism and its application in engineering and related fields. EM fundamentals. EM spectrum, radiation, radiating systems, wireless, modern concepts of physics, quantum computing, transmission lines, high speed effects, waveguides, GPS and other related phenomena will be discussed and explained with the application in mind. Nonmajor graduate credit.

E E 321. Communication Systems I.  
(3-0) Cr. 3. F. Prereq: E E 224  

E E 322. Probabilistic Methods for Electrical Engineers.  
(Cross-listed with STAT). (3-0) Cr. 3. F,S. Prereq: E E 224  
Introduction to probability with applications to electrical engineering. Sets and events, probability space, conditional probability, total probability and Bayes’ rule. Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, moments, moment generating functions, multiple random variables, functions of random variables. Elements of statistics, hypothesis testing, confidence intervals, least squares. Introduction to random processes.

E E 323. Introduction to Digital Signal Processing.  
(3-3) Cr. 4. Prereq: E E 224  

E E 324. Signals and Systems II.  
(3-3) Cr. 4. F. Prereq: E E 224  

E E 325. Systems Biology for Engineering.  
(Cross-listed with BIOE). (3-0) Cr. 3. Prereq: BIOE 210, MATH 267  

E E 330. Integrated Electronics.  
(Cross-listed with CPR E). (3-3) Cr. 4. Prereq: E E 201, credit or enrollment in E E 230, CPR E 281  
Semiconductor technology for integrated circuits. Modeling of integrated devices including diodes, BJTs, and MOSFETs. Physical layout. Circuit simulation. Digital building blocks and digital circuit synthesis. Analysis and design of analog building blocks. Laboratory exercises and design projects with CAD tools and standard cells. Nonmajor graduate credit. Credit for only one of E E 330 or 331 may be counted toward graduation.

E E 332. Semiconductor Materials and Devices.  
(Cross-listed with MAT E). (3-0) Cr. 3. S. Prereq: PHYS 222; MAT E majors: MAT E 334; CPR E and E E majors: E E 230  
Introduction to semiconductor material and device physics. Quantum mechanics and band theory of semiconductors. Charge carrier distributions, generation/ recombination, transport properties. Physical and electrical properties and fabrication of semiconductor devices such as MOSFETs, bipolar transistors, laser diodes and LED’s. Nonmajor graduate credit.

(2-2) Cr. 3. Prereq: E E 188, E E 224, E E 230  
Principles and practices of biomedical instrumentation. Topics include: the physics and measurement of biopotentials including electrocardiography (EKG), electromyography (EMG) and electro-occulography (EOG), mechanical and chemical sensors, amplifiers and filters, recording and processing biological signals from nerve cells, muscles and human body, electrode polarization, surface electrodes, power line interference, heart sound sensors, respiratory gas concentration, blood-gas sensors, noninvasive blood-gas sensors.

(3-0) Cr. 3. Prereq: MATH 185  
E E 388. Sustainable Engineering and International Development.
(Cross-listed with A E, C E, M E, MAT E, BSE). (2-2) Cr. 3. F. Prereq: Junior classification in engineering
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report. Meets International Perspectives Requirement.

E E 394. Program Exploration.
(Cross-listed with CPR E). Cr. R. Prereq: CPR E 294 or E E 294
Exploration of academic and career fields for electrical and computer engineers. Examination of professionalism in the context of engineering and technology with competencies based skills. Introduction to professional portfolio development and construction. Offered on a satisfactory-fail basis only.

E E 396. Summer Internship.
Cr. R. Repeatable. SS. Prereq: Permission of department and Engineering Career Services
One semester maximum per academic year professional work period. Students must register for this course before commencing work.

E E 397. Engineering Internship.
Cr. R. Repeatable. F.S. Prereq: Permission of department and Engineering Career Services
One semester maximum per academic year professional work period. Students must register for this course before commencing work.

E E 398. Cooperative Education.
Cr. R. F.S.SS. Prereq: E E 298, permission of department and Engineering Career Services
Second professional work period. Students must register for this course before commencing work.

E E 414. Microwave Engineering.
(Dual-listed with E E 514). (3-3) Cr. 4. F. Prereq: E E 230, E E 311
Principles, analyses, and instrumentation used in the microwave portion of the electromagnetic spectrum. Wave theory in relation to circuit parameters. S parameters, couplers, discontinuities, and microwave device equivalent circuits. RF amplifier design, microwave sources, optimum noise figure and maximum power designs. Microwave filters and oscillators. Nonmajor graduate credit.

(Dual-listed with E E 517). (3-3) Cr. 4. S. Prereq: E E 311

(Cross-listed with CPR E). (3-3) Cr. 4. F. Prereq: E E 230 and CPR E 311

E E 422. Communication Systems II.
(3-0) Cr. 3. Prereq: E E 421 and enrollment in E E 423
Introduction to probability and random processes; Performance of analog systems with noise; Performance of digital communication with noise; optimum receivers, transmission impairments, and error rates; Introduction to information theory and coding; source coding, channel coding, channel capacity. Nonmajor graduate credit.

E E 423. Communication Systems Laboratory.
(0-3) Cr. 1. Prereq: E E 421, enrollment in E E 422
Construction and evaluation of modulators, demodulators and other components for analog and digital communications. Design, simulate, and evaluate wireless communication systems and their key components. Noise measurement. Nonmajor graduate credit.

E E 432. Microelectronics Fabrication Techniques.
(Dual-listed with E E 532). (3-3) Cr. 3. F. Prereq: PHYS 222, MATH 267, E E 332 or E E 334 recommended
Techniques used in modern integrated circuit fabrication, including diffusion, oxidation, ion implantation, lithography, evaporation, sputtering, chemical-vapor deposition, and etching. Process integration. Process evaluation and final device testing. Extensive laboratory exercises utilizing fabrication methods to build electronic devices. Use of computer simulation tools for predicting processing outcomes. Recent advances in processing CMOS ICs and micro-electronic mechanisms (MEMS). Nonmajor graduate credit.

(Cross-listed with CPR E). (3-3) Cr. 3. F. Prereq: E E 324, E E 330, E E 332, and either E E 322 or STAT 330
Basic analog integrated circuit and system design including design space exploration, performance enhancement strategies, operational amplifiers, references, integrated filters, and data converters. Nonmajor graduate credit.

(Cross-listed with E E 538). (3) Cr. 3. S. Prereq: E E 311, E E 332

(Cross-listed with E E 539). (3-0) Cr. 3. S. Prereq: E E 332/MAT E 332 or MAT E 331
Concepts of quantum mechanics relevant to nanoelectronic devices, including quantization, tunneling, and transport; overview of some of the leading technologies for nanoelectronics, including carbon nanotubes, quantum dots, and molecular transistors; fabrication methods for building nanoelectronic devices. Nonmajor graduate credit.

E E 442. Introduction to Circuits and Instruments.
(3-2) Cr. 2. F. Prereq: PHYS 222, MATH 267
Half-semester course. Basic circuit analysis using network theorems with time domain and Laplace transform techniques for resistive, resistive-inductive, resistive-capacitive, and resistive-inductive-capacitive circuits. Transient circuit behavior. Basic operational amplifiers and applications. Familiarization with common E E instrumentation and demonstration of basic principles. Nonmajor graduate credit. Credit for only 201 or 442 may be counted toward graduation; credit for 442 will not count toward graduation for E E or CPR E majors.

E E 448. Introduction to AC Circuits and Motors.
(3-2) Cr. 2. F. Prereq: E E 303 or E E 441 or E E 442

(2-2) Cr. 3. Alt. S., offered 2012. Prereq: Phys 221 and Math 266 or 267
Sound sources and propagation. Noise standards and effects of noise on people. Principles of noise and vibration control used in architectural and engineering design. Characteristics of basic noise measurement equipment. Experience in use of noise measuring equipment, sound power measurements, techniques for performing noise surveys, evaluation of various noise abatement techniques applied to common noise sources. Selected laboratory experiments. Nonmajor graduate credit.

E E 452. Electrical Machines and Power Electronic Drives.
(2-3) Cr. 3. S. Prereq: E E 303; E E 330 or E E 332; credit or registration in E E 324
Basic concepts of electromagnetic energy conversion. DC motors and three-phase induction motors. Basic introduction to power electronics. Adjustable speed drives used for control of DC, induction, and AC motors. Experiments with converter topologies, DC motors, AC motors and adjustable speed drives. Nonmajor graduate credit.

E E 455. Introduction to Energy Distribution Systems.
(3-0) Cr. 3. F. Prereq: E E 303, credit or registration in E E 324
Overhead and underground distribution system descriptions and characteristics, load descriptions and characteristics, overhead line and underground cable models, distribution transformers, power flow and fault analysis, overcurrent protection, power factor correction, system planning and automation, and economics in a deregulated environment. Nonmajor graduate credit.
E E 456. Power System Analysis I.  (3-0) Cr. 3. F. Prereq: E E 303, credit or registration in E E 324
Power transmission lines and transformers, synchronous machine modeling, network analysis, power system representation, load flow. Nonmajor graduate credit.

E E 457. Power System Analysis II.  (3-0) Cr. 3. S. Prereq: E E 303, credit or registration in E E 324
Power system protection, symmetrical components, faults, stability. Power system operations including the new utility environment. Nonmajor graduate credit.

E E 458. Economic Systems for Electric Power Planning.  (Cross-listed with ECON).  (3-0) Cr. 3. Prereq: E E 303 or ECON 301

E E 459. Electromechanical Wind Energy Conversion and Grid Integration.  (Dual-listed with E E 559).  (3-0) Cr. 3. Prereq: Credit or enrollment in E E 452, E E 456
Summary of industry status and expected growth; power extraction from the air stream; operation and modeling of electric machines, and power electronics topologies for wind energy conversion; analysis of machine-grid power electronic circuits, controller interface, and collector (distribution) networks; treatment of harmonics, flicker, over/under-voltages, filters, low-voltage ride-through, and reactive compensation; relaying; effects on transmission expansion, planning and grid operation and coordination including variability, frequency control, reserves, and electricity markets; overview of storage technologies and hybrid configurations. Nonmajor graduate credit.

Digital design of integrated circuits employing very large scale integration (VLSI) methodologies. Technology considerations in design. High level hardware design languages, CMOS logic design styles, area-energy-delay design space characterization, datapath blocks: arithmetic and memory, architectures and systems on a chip (SOC) considerations. VLSI chip hardware design project. Nonmajor graduate credit.

E E 466. Multidisciplinary Engineering Design.  (Cross-listed with A E, AER E, CPR E, ENGR, I E, M E, MAT E).  (1-4) Cr. 3. Prereq: Student must be within two semesters of graduation and receive permission of instructor
Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing, and life cycle considerations. Application of design tools such as CAD, CAM, and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations and computer models and engineering drawings.

E E 467. Multidisciplinary Engineering Design II.  (Cross-listed with AER E, CPR E, ENGR, I E, MAT E, M E).  (1-4) Cr. 3. Prereq: Repeatable, maximum of 2 times. F.S. Prereq: Student must be within two semesters of graduation or receive permission of instructor
Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

E E 475. Automatic Control Systems.  (3-0) Cr. 3. F. Prereq: E E 324

E E 476. Control System Simulation.  (2-3) Cr. 3. S. Prereq: E E 447
Computer aided techniques for feedback control system design, simulation, and implementation. Nonmajor graduate credit.

E E 488. Eddy Current Nondestructive Evaluation.  (Dual-listed with E E 588).  (Cross-listed with MAT E).  (3-0) Cr. 3. Alt. F., offered 2013. Prereq: MATH 265 and (MAT E 216 or MAT E 272 or E E 311 or PHYS 364)
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a virtual eddy current instrument will demonstrate key concepts.

E E 490. Independent Study.  Cr. arr. Prereq: Senior classification in electrical engineering
Investigation of an approved topic commensurate with the student’s prerequisites.

E E 490H. Independent Study: Honors.  Cr. arr. Prereq: Senior classification in electrical engineering
Investigation of an approved topic commensurate with the student’s prerequisites.

E E 491. Senior Design Project I and Professionalism.  (Cross-listed with CPR E).  (2-3) Cr. 3. F. S. Prereq: E E 322 or CPR E 308, completion of 24 credits in the E E core professional program or 29 credits in the CPR E core professional program, ENGL 314
Preparing for entry to the workplace. Selected professional topics. Use of technical writing skills in developing project plan and design report; design review presentation. First of two-semester team-oriented, project design and implementation experience.

E E 492. Senior Design Project II.  (Cross-listed with CPR E).  (1-3) Cr. 2. F. S. Prereq: CPR E 491 or E E 491
Second semester of a team design project experience. Emphasis on the successful implementation and demonstration of the design completed in E E 491 or CPR E 491 and the evaluation of project results. Technical writing of final project report; oral presentation of project achievements; project poster.

E E 494. Portfolio Assessment.  (Cross-listed with CPR E).  Cr. R. Prereq: CPR E 394 or E E 394, credit or enrollment in CPR E 491 or E E 491
Portfolio update and evaluation. Portfolios as a tool to enhance career opportunities.

E E 496. Modern Optics.  (Cross-listed with PHYS).  (3-0) Cr. 3. S. Prereq: Credit or enrollment in PHYS 322, PHYS 365, and PHYS 480
Review of wave and electromagnetic theory; topics selected from: reflection/ refraction, interference, geometrical optics, Fourier analysis, dispersion, coherences, Fraunhofer and Fresnel diffraction, holoigraphy, quantum optics, nonlinear optics. Nonmajor graduate credit.

Third and subsequent professional work periods in the cooperative education programs. Students must register for this course before commencing work.

Courses primarily for graduate students, open to qualified undergraduates:


E E 504. Power Management for VLSI Systems.  (Cross-listed with CPR E).  (3-3) Cr. 4. Prereq: E E 435, Credit or Registration for E E 501
Theory, design and applications of power management and regulation circuits (Linear and switching regulators, battery chargers, and reference circuits) including: Architectures, Performance metrics and characterization, Noise and stability analysis, Practical implementation and on-chip integration issues, design considerations for portable, wireless, and RF SoCs.

Theory, design and applications of data conversion circuits (A/D and D/A converters) including: architectures, characterization, quantization effects, conversion algorithms, spectral performance, element matching, design for yield, and practical comparators, implementation issues.
E E 506. Design of CMOS Phase-Locked Loops. (Cross-listed with CPR E). (3-3) Cr. 4. Prereq: E E 435 or E E 501 or instructor approval
Analysis and design of phase-locked loops implemented in modern CMOS processes including: architectures, performance metrics, and characterization; noise and stability analysis; and design issues of phase-frequency detectors, charge pumps, loop filters (passive and active), voltage controlled oscillators, and frequency dividers.

E E 507. VLSI Communication Circuits. (Cross-listed with CPR E). (3-3) Cr. 4, Alt. S., offered 2013. Prereq: CPR E 330 or CPR E 501
Radio frequency integrated circuits for wireless and wired communications with a focus on CMOS implementations. Discussions on fundamental concepts in RF design such as nonlinearity, sensitivity, and dynamic range will be followed with a detailed analysis and design of low-noise amplifiers, mixer, oscillators, and transceivers.

E E 508. Filter Design and Applications. (3-3) Cr. 4. Prereq: E E 501

Axioms of probability; Repeated trials; Functions of a random variable and multiple random variables: covariance matrix, conditional distribution, joint distribution, moments, and joint moment generating function; Mean square estimation; stochastic convergence; Some important stochastic processes: Random walk, Poisson, Wiener, and shot noise; Markov chains; Power spectral analysis; Selected applications.

E E 511. Advanced Electromagnetic Field Theory I. (3-0) Cr. 3. F. Prereq: E E 311

E E 512. Advanced Electromagnetic Field Theory II. (3-0) Cr. 3. S. Prereq: E E 512

E E 514. Microwave Engineering. (Dual-listed with E E 414). (3-3) Cr. 4, F. Prereq: E E 230, E E 311
Principles, analyses, and instrumentation used in the microwave portion of the electromagnetic spectrum. Wave theory in relation to circuit parameters. S parameters, couplers, discontinuities, and microwave device equivalent circuits. RF amplifier design, microwave sources, optimum noise figure and maximum power designs. Microwave filters and oscillators.

E E 516. Computational Methods in Electromagnetics. (3-0) Cr. 3. S. Prereq: E E 311

E E 517. Electromagnetic Radiation, Antennas, and Propagation. (Dual-listed with E E 417). (3-3) Cr. 4. S. Prereq: E E 311

E E 518. Microwave Remote Sensing. (Cross-listed with AGRON, METEOR). (3-0) Cr. 3. Alt. S., offered 2012. Prereq: Math 265 or equivalent
Microwave remote sensing of Earth’s surface and atmosphere using satellite-based or ground-based instruments. Specific examples include remote sensing of atmospheric temperature and water vapor, precipitation, ocean salinity, and soil moisture.

E E 519. Magnetism and Magnetic Materials. (Cross-listed with M S E). (3-0) Cr. 3. F. Prereq: E E 311, MAT E 211 or E E 271 or E E 272 or PHYS 364

E E 520. Selected Topics in Communications and Signal Processing. (3-0) Cr. 3. Repeatable.

E E 521. Advanced Communications. (3-0) Cr. 3. F. Prereq: E E 422, Coreq: E E 523

E E 523. Random Processes for Communications and Signal Processing. (3-0) Cr. 3. Prereq: E E 322, MATH 317
Axioms of probability; Repeated trials; Functions of a random variable and multiple random variables: covariance matrix, conditional distribution, joint distribution, moments, and joint moment generating function; Mean square estimation; stochastic convergence; Some important stochastic processes: Random walk, Poisson, Wiener, and shot noise; Markov chains; Power spectral analysis; Selected applications.

E E 524. Digital Signal Processing. (3-0) Cr. 3. F. Prereq: E E 322, E E 424, MATH 317

E E 527. Detection and Estimation Theory. (3-0) Cr. 3. S. Prereq: E E 422

E E 528. Digital Image Processing. (3-0) Cr. 3. S. Prereq: E E 322, E E 424
Review of sampling, linear algebra and probability. Classical image processing topics such as image sampling and quantization, image transforms (2D Fourier, KLT, DCT, etc), image enhancement, restoration and filtering. Image analysis topics including edge detection, segmentation, registration and tracking (uses least squares estimation, EM, Kalman filter). Medical image reconstruction from tomographic projections (Radin transform, Fourier slice theorem and reconstruction algorithms using them) and Magnetic Resonance Imaging (MRI). Basic introduction to image and video compression methods.

E E 530. Selected Topics in Electronics, Microelectronics and Photonics. (3-0) Cr. 3. Repeatable. Prereq: E E 332

E E 532. Microelectronics Fabrication Techniques. (Dual-listed with E E 432). (Cross-listed with MAT E). (2-4) Cr. 4. Prereq: PHYS 222, MATH 267, E E 332 or MAT E 331 recommended
Techniques used in modern integrated circuit fabrication, including diffusion, oxidation, ion implantation, lithography, evaporation, sputtering, chemical-vapor deposition, and etching. Process integration. Process evaluation and final device testing. Extensive laboratory exercises utilizing fabrication methods to build electronic devices. Use of computer simulation tools for predicting processing outcomes. Recent advances in processing CMOS ICs and micro-electromechanical systems (MEMS).
(Cross-listed with PHYS). (3-3) Cr. 4. Prereq: E E 311 and E E 332
Basic elements of quantum theory, Fermi statistics, motion of electrons in periodic structures, crystal structure, energy bands, equilibrium carrier concentration and doping, excess carriers and recombination, carrier transport at low and high fields, space charge limited current, photo-conductivity in solids, phonons, optical properties, amorphous semiconductors, heterostructures, and surface effects. Laboratory experiments on optical properties, carrier lifetimes, mobility, defect density, doping density, photo-conductivity, diffusion length of carriers.

(Cross-listed with PHYS). (3-0) Cr. 3. Prereq: E E 535
P-n junctions, band-bending theory, tunneling phenomena, Schottky barriers, heterojunctions, bipolar transistors, field-effect transistors, negative-resistance devices and optoelectronic devices.

E E 538. Optoelectronic Devices and Applications.
(Dual-listed with E E 438). (3-0) Cr. 3. Prereq: E E 311 or E E 332

(Cross-listed with M S E). (3-0) Cr. 3. Prereq: E E 324 or MAT E 331 or PHYS 322
Review of classical and quantum mechanical descriptions of electrons in solids, band theory, metallic conduction, lattice vibrations, semiconductors, semiconductor devices, dielectrics, polarization, dielectric relaxation, crystal anisotropy, ferroelectricity, piezoelectricity, superconductivity, magnetism, device applications.

E E 545. Artificial Neural Networks.
(3-0) Cr. 3. F. Prereq: E E 324

E E 547. Pattern Recognition.
(3-0) Cr. 3. F. Prereq: E E 324

E E 553. Steady State Analysis.
(3-0) Cr. 3. F. Prereq: E E 456, E E 457
Power flow, economic dispatch, unit commitment, electricity markets, automatic generation control, sparse matrix techniques, interconnected operation, voltage control.

E E 554. Power System Dynamics.
(3-0) Cr. 3. S. Prereq: E E 456, E E 457, E E 475
Dynamic performance of power systems with emphasis on stability. Modeling of system components and control equipment. Analysis of the dynamic behavior of the system in response to small and large disturbances.

(3-0) Cr. 3. Prereq: E E 455
Transient models of distribution components, automated system planning and distribution automation, surge protection, reliability, power quality, power electronics and intelligent systems applications.

(3-0) Cr. 3. Prereq: E E 452
Converter topologies, AC/DC, DC/DC, DC/AC, AC/AC. Converter applications to do motor drives, power supplies, AC motor drives, power system utility applications (var compensators) and power quality.

E E 559. Electromechanical Wing Energy Conversion and Grid Integration.
(Dual-listed with E E 459). (3-0) Cr. 3. Prereq: Credit or enrollment in E E 452, E E 456
Summary of industry status and expected growth; power extraction from the air stream; operation and modeling of electric machines, and power electronics topologies for wind energy conversion; analysis of machine-grid power electronic circuits, controller interface, and collector (distribution) networks; treatment of harmonics, flicker, over-under-voltages, filters, low-voltage ride-through, and reactive compensation; relaying; effects on transmission expansion, planning and grid operation and coordination including variability, frequency control, reserves, and electricity markets; overview of storage technologies and hybrid configurations. Nonmajor graduate credit.

E E 565. Systems Engineering and Analysis.
(Cross-listed with AER E, I E). (3-0) Cr. 3. Prereq: Coursework in basic statistics
Introduction to organized multidisciplinary approach to designing and developing systems. Concepts, principles, and practice of systems engineering as applied to large integrated systems. Life cycle costing, scheduling, risk management, functional analysis, conceptual and detail design, test and evaluation, and systems engineering planning and organization. Not available for degrees in industrial engineering.

(Cross-listed with AER E). (3-0) Cr. 3. S. Prereq: E E 565
Avionics functions. Applications of systems engineering principles to avionics. Top down design of avionics systems. Automated design tools.

E E 570. Systems Engineering Analysis and Design.
(3-0) Cr. 3. Prereq: E E 475, E E 577
Selected topics in abstract algebra, linear algebra, real analysis, functional analysis, and optimization methods in electrical engineering.

E E 571. Introduction to Convex Optimization.
(3-0) Cr. 3.
Introduction to convex optimization problems emerging in electrical engineering. Efficiently solving convex optimization problems with the use of interior point algorithms software. Review of linear algebra, convex functions, convex sets, convex optimization problems, duality, disciplined convex programming, applications to optimal filtering, estimation, control and resources allocations, sensor network, distributed systems.

(Cross-listed with AER E, MATH, M E). (3-0) Cr. 3. F. Prereq: E E 324 or AER E 331 or M E 370 or M E 411 or MATH 341

E E 574. Optimal Control.
(Cross-listed with AER E, MATH, M E). (3-0) Cr. 3. S. Prereq: E E 577

E E 575. Introduction to Robust Control.
(Cross-listed with MATH, AER E, M E). (3-0) Cr. 3. Prereq: E E 577

(Cross-listed with AER E, MATH, M E). (3-0) Cr. 3. F. Prereq: E E 475 or AER E 432 or M E 411 or 414 or MATH 415; and MATH 267
EE 577. Linear Systems.
(Cross-listed with AER E, MATH, M E). (3-0) Cr. 3. F. Prereq: E E 324 or AER E 331 or MATH 415; and MATH 307

EE 578. Nonlinear Systems.
(Cross-listed with AER E, MATH, M E). (3-0) Cr. 3. S. Prereq: E E 577

(Dual-listed with E E 488). (Cross-listed with M S E). (3-0) Cr. 3. Alt. F., offered 2011. Prereq: MATH 265 and (MAT E 216 or MAT E 272 or E E 311 or PHYS 364)
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a 'virtual' eddy current instrument will demonstrate key concepts.

EE 590. Special Topics.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590A. Special Topics: Electromagnetic Theory.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590B. Special Topics: Control Systems.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590C. Special Topics: Communication Systems.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590E. Special Topics: Computer Engineering.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590F. Special Topics: Electric Power.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590G. Special Topics: Electrical Materials.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590H. Special Topics: Electronic Devices and Circuits.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 590I. Special Topics: Signal Processing.
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.

EE 591. Seminar in Electronics, Microelectronics, and Photonics.
Cr. 1-3. Repeatable.

EE 594. Seminar in Electric Power.
Cr. 1-3. Repeatable.

EE 596. Seminar in Control Systems.
Cr. 1-3. Repeatable.

EE 597. Seminar in Communications and Signal Processing.
Cr. 1. Repeatable. Offered on a satisfactory-fail basis only.

EE 599. Creative Component.
Cr. arr. Repeatable.

Courses for graduate students:

EE 621. Coding Theory.
(3-0) Cr. 3. Prereq: E E 521

EE 622. Information Theory.
(3-0) Cr. 3. Prereq: E E 521, E E 523
Information system overview. Entropy and mutual information. Data Compression and source encoding. Discrete memoryless channel capacity. Noisy channel coding theorem. Rate distortion theory. Waveform channels. Advanced topics in information theory.

EE 653. Advanced Topics in Electric Power System Engineering.
(3-0) Cr. 3. Repeatable. Prereq: Permission of instructor
Advanced topics of current interest in electric power system engineering.

EE 674. Advanced Topics in Systems Engineering.
(3-0) Cr. 3. Repeatable. Prereq: Permission of instructor
Advanced topics of current interest in the areas of control theory, stochastic processes, digital signal processing, and image processing.

EE 697. Engineering Internship.
(Cross-listed with CPR E). Cr. R. Repeatable.
One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

EE 699. Research.
Cr. arr. Repeatable.