Help! Guide
Fall 2014-Spring 2015

Department of Electrical, Computer, and Energy Engineering
University of Colorado at Boulder
Engineering Center
Main Office - Room ECEE 1B55
425 UCB
Boulder, CO 80309-0425

http://ecee.colorado.edu/
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Welcome to Electrical, Computer, and Energy Engineering

Welcome
Mission and Objectives for the EE/ECE Undergraduate Programs
Electrical, Computer, and Energy Engineering Disciplines
Program Objectives for a BS Degree in Electrical Engineering
Program Objectives for a BS Degree in Electrical & Computer Engineering
Welcome to the ECEE Department!

We are pleased you have chosen the Electrical, Computer, and Energy Engineering Department to help pursue your career goals. The department offers two baccalaureate degrees, a B.S. in Electrical Engineering and a B.S. in Electrical and Computer Engineering. Both degree programs are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

This HELP! Guide has been written to assist you in understanding department curriculum requirements and regulations. You should also be familiar with the Advising Guides published by the Dean’s Office. In cases where department rules differ from those of the College, the department rules supersede. You are responsible for knowing both sets of rules.

Because the curriculum is continually changing, you are expected to follow the curriculum in effect when you entered the program, as reflected in this HELP! Guide.

The ECEE faculty and staff are here to help you with whatever problems you may encounter along the way. You should become familiar with the people listed in the box on this page.

As a freshman, you should see any of the freshman advisors or the Undergraduate Staff Advisor when you have questions. At the beginning of your sophomore year, you will be assigned a permanent faculty advisor for the remainder of your program.

If you have questions about curriculum requirements, department regulations, course sequences, etc., the Undergraduate Staff Advisor is the person to contact. She can perform a degree audit which will tell you the courses you have already completed and also which courses you still need to take to complete your degree requirements. If you have technical questions about course content, or the desirability of certain courses in the marketplace, see a freshman advisor or your faculty advisor. Your faculty advisor may also assist you with career counseling and other similar topics.

When rearranging courses to fit your particular needs, be sure to consider how postponing a course that is a prerequisite to others will affect the remainder of your schedule. You will find that some courses may be moved without penalty, while postponing others will delay your graduation by a semester or more. As you will see in the curriculum guide, many courses are only offered once an academic year.

College is very different from high school. You are expected to take much more initiative in such things as arranging your own schedule, gathering information, and seeking help when needed.

If you find you need help – whether for academic or personal difficulties – there are many resources available on this campus. Please come see us before a problem becomes serious. If we can’t help you solve your problem, we can refer you to someone who can help.

Information is also available on the ECEE Department web page at: http://ecee.colorado.edu

Check regularly for updated schedules, course information, faculty email addresses, phone numbers and office locations, and much more.

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**Electrical, Computer, & Energy Engineering Advisors**

**Associate Chair and Head of the Undergraduate Programs:**
- **Prof. Peter Mathys**  
  ECEE 1B67  
  303-492-7733

**Undergraduate Academic Staff Advisor:**
- **Ms. Valerie Matthews**  
  ECEE 1B20  
  303-492-7671

**Freshman Advisors:**
- **Prof. Andrew Pleszku**  
  ECOT 334
- **Prof. Juliet Gopinath**  
  ECEE 1B43

**Transfer Credit Evaluator:**
- **Prof. Melinda Piket-May** (fall)  
  ECOT 240
- **Prof. Ed Kuester** (spring)  
  ECOT 248

**Academic and Career Advisors:**
- Your assigned faculty advisor or any ECEE faculty member

**Career Advising outside the department:**
- Career Services Office  
  Center for Community N352  
  http://careerservices.colorado.edu/public/
Mission and Objectives for the EE/ECE Undergraduate Programs

Department Overview
The department was founded in the 1890’s, in the earliest days of the College of Engineering. Today it has 39 tenured and tenure-track professors, 10 professors with secondary appointments to the department, 3 research professors, and over 10 adjunct professors, instructors, and lecturers.

Two of our faculty are members of the National Academy of Engineering, fourteen are Institute of Electrical and Electronics Engineers (IEEE) Fellows, three are Optical Society of America Fellows and eight are members of Eta Kappa Nu, the national Electrical and Computer Engineering honors society.

Our faculty are active in research, with research expenditures totaling about $6.8 million annually. Our research is concentrated in ten different areas, from biomedical engineering to VLSI/CAD.

Mission Statement
The Department of Electrical, Computer, and Energy Engineering at the University of Colorado at Boulder is the premier undergraduate and graduate EE/ECE program in the state of Colorado and all adjoining states, as measured by reputation, national rankings, and department size. The primary mission of the ECEE Department is:

• To provide relevant and highly-respected undergraduate EE and ECE degree programs to on-campus students,
• To provide excellent graduate degree programs in electrical and computer engineering,
• To advance industry in the state of Colorado and the nation, as well as the accumulated knowledge of humanity, through our high quality research programs, and
• To use our on-campus educational activities to provide high-quality continuing education programs for off-campus students.

It is widely acknowledged that an engineering undergraduate education is a strong foundation for a successful career in many different disciplines including, of course, engineering, but additionally in management, business, law, medicine and even politics. While our primary focus is on engineering careers we are pleased when our graduates take their foundations in analysis, problem solving and understanding of complex systems into diverse careers.

Our curriculum is designed to help our graduates become viable in a globally competitive work environment. Our graduates are able to establish a portfolio of up-to-date skills, abilities, and accomplishments that distinguish them from the competition. Further, the core disciplines and intellectual skills they develop form the framework for a successful career in an environment where the state of practice advances rapidly.

Employment Opportunities
According to the Bureau of Labor Statistics, electrical, electronics, and computer engineers make up the largest branch of engineering. They are found in professional, scientific, and technical services firms, government agencies, manufacturers of computer and electronic products and machinery, wholesale trade, communications, and utilities firms. On the CU-Boulder campus, recruiters request interviews with electrical engineering and computer engineering graduates in numbers several times those of other majors, even other engineering majors.

Our graduates go to work for both large engineering companies (Lockheed Martin, IBM, Agilent, Hewlett Packard, Xilinx, Intel, Northrup Grumman, Ball Aerospace, Maxtor, Seagate, Sun Microsystems, National Instrument, Texas Instruments, Apple Computers, Micron) and smaller, local firms such as SpectraLogic and Level 3 Communications. Some of our graduates go on to graduate school and occasionally our graduates start their own companies.
Biomedical and Neural Engineering
Biomedical engineering is concerned with the development and manufacture of prostheses, medical devices, diagnostic devices, drugs, and other therapies. It is more concerned with biological, safety, and regulatory issues than other disciplines in engineering. Our faculty are currently pursuing research in bioelectromagnetics which involves the use of electromagnetic fields to probe biological functions, MRI, and other diagnostic tools.

Communications and Signal Processing
Communication engineering and information theory are concerned with the efficient representation and reliable transmission and/or storage of information. Communications engineers develop: digital audio, pattern recognition, speech processing and recognition, audio and image compression, medical imaging, digital filtering, and more.

Computer Engineering
A computer engineer is an electrical engineer with a focus on digital logic systems, and less emphasis on radio frequency or power electronics. From a computer science perspective, a computer engineer is a software architect with a focus on the interaction between software programs and the underlying hardware components.

Dynamics and Controls
Control techniques are used whenever some quantity, such as speed, temperature, or force must be made to behave in some desirable way over time. Currently, our dynamics and controls group are working on diverse problems such as developing controllers for aircraft, spacecraft, information storage systems, human-machine interfaces, manufacturing processes, and power systems.

Electromagnetics, RF, and Microwaves
This specialty area is concerned with the use of the electromagnetic spectrum. In particular, our faculty focus on current commercial and military needs such as active circuits, antennas for communications and radar, theoretical and numerical techniques for analysis of high-frequency circuits and antennas, and artificial electromagnetic materials.

Nanostructures and Devices
Solid-state devices form the basis of integrated circuits, which have a variety of electronic, optoelectronic, and magnetic applications. The research in this field is concerned with the design, fabrication, and characterization of novel materials and devices with sub-micron feature sizes. Their potential applications include very high-speed devices, optical sources and detectors, optoelectronic components and all-optical devices. The design and fabrication of devices and integrated circuits are inextricably related to device physics, solid-state materials, and sophisticated processing techniques.

Optics and Photonics
This area emphasizes the design, fabrication, and characterization of materials, devices and systems for the generation, transmission, amplification, detection, and processing of light signals. These are enabling and pervasive technologies applied in fields like communications, sensing, bio-medical instrumentation, consumer electronics and defense.

Power Electronics and Renewable Energy Systems
Power electronics is the technology associated with the efficient conversion, control and conditioning of electronic power by static means from its available input form into the desired electrical output form. In contrast to electronic systems concerned with transmission and processing of signals and data, in power electronics substantial amounts of electrical energy are processed.

VLSI/CAD
Very Large Scale Integration – a term applied to most modern integrated circuits which comprise from hundreds to thousands to millions of individual components. Research in this area works toward developing new algorithms and design methodologies to efficiently design VLSI integrated circuits.
Program Objectives for a BS Degree in Electrical Engineering
Department of Electrical, Computer, & Energy Engineering

EE-1  Graduates will be situated in growing careers involving the design, development or support of electrical or electronic systems, devices, instruments, or products, or will be successfully pursuing an advanced degree.

Graduates attaining the EE degree will have comprehensive knowledge and experience in the concepts and design of electrical and electronic devices, circuits, and systems. This is achieved through a sequence of required courses in these areas, culminating in a major design project incorporating realistic engineering constraints. Moreover, graduates will have advanced, specialized knowledge and skills in elective areas such as communications and digital signal processing, control systems, analog and digital integrated circuit design, semiconductor devices and optoelectronics electromagnetics and wireless systems, power electronics and renewable energy, bioelectronics, and digital systems.

EE graduates will have attained other professional skills that will be useful throughout their careers, including verbal and written communication and the ability to function on multi-disciplinary teams.

The EE curriculum is rich in laboratory work. EE graduates will have achieved extensive practical experience in the laboratory techniques, tools, and skills that provide a bridge between theory and practice.

EE-2  Graduates will have advanced in professional standing based on their technical accomplishments, and will have accumulated additional technical expertise to remain globally competitive.

EE graduates experience a curriculum that contains a broad core of classes focused on mathematical and physical principles that are fundamental to the field of electrical engineering. Hence, they understand the physical and mathematical principles underlying electrical and electronic technology, and are able to analyze and solve electrical engineering problems using this knowledge. In addition to basic classes in mathematics, science, and computing, the EE curriculum includes a sequence of courses in analog and digital electronic circuits and systems, and electromagnetic fields.

EE-3  Graduates will have demonstrated professional and personal leadership and growth.

To lay the foundation for a long career in a rapidly changing field, a broad background of fundamental knowledge is required. This is achieved in the EE curriculum through a sequence of required classes in mathematics, physics, chemistry, and the EE core. In addition, the graduate must be capable of lifelong learning; this is taught through assignments and projects that require independent research and study.

The curriculum includes a significant component of electives in the humanities and social sciences. EE graduates will have knowledge of the broader contemporary issues that impact engineering solutions in a global and societal context. They will have the verbal and written communications skills necessary for a successful career in industry or academia. Graduates also understand the meaning and importance of professional and ethical responsibility.
Program Objectives for a BS Degree in Electrical & Computer Engineering
Department of Electrical, Computer, & Energy Engineering

ECE-1 Graduates will be situated in growing careers involving the design, development or support of electrical, electronic, and computer hardware and software systems, software engineering, devices instruments, or products, or will be successfully pursuing an advanced degree.

Graduates attaining the ECE degree will have comprehensive knowledge and experience in the concepts and design of electrical, electronic, and computer devices, circuits, and systems. Besides emphasizing computer hardware and software, the ECE curriculum also emphasizes design, integration, implementation, and application of computer systems, as well as experience in software development. This is achieved through a sequence of required courses in these areas, culminating in a major design project incorporating realistic engineering constraints. The curriculum also provides opportunities for specialization in areas such as compiler design, embedded systems, software engineering, and VLSI design, as well as in the electrical engineering specialties.

ECE graduates will have attained other professional skills that will be useful throughout their careers, including verbal and written communication and the ability to function on multi-disciplinary teams.

The ECE curriculum is rich in laboratory work. ECE graduates will have achieved extensive practical experience in the laboratory techniques, tools, and skills that provide a bridge between theory and practice.

ECE-2 Graduates will have advanced in professional standing based on their technical accomplishments and will have accumulated additional technical expertise to remain globally competitive.

ECE graduates experience a curriculum that contains a broad core of classes focused on mathematical and physical principles that are fundamental to the fields of electrical and computer engineering. Hence, they understand the physical and mathematical principles underlying electrical and electronic technology and computer systems, and are able to analyze and solve electrical and computer engineering problems using this knowledge. In addition to basic classes in mathematics, science, and computing, the ECE curriculum includes a sequence of courses in analog and digital electronic circuits and systems, electromagnetic fields, probability, computer software, and computer design and architecture.

ECE-3 Graduates will have demonstrated professional and personal leadership and growth.

To lay the foundation of a long career in a rapidly changing field, a broad background of fundamental knowledge is required. This is achieved in the ECE curriculum through a sequence of required classes in mathematics, physics, chemistry, and the ECE core. In addition, the graduate must be capable of lifelong learning; this is taught through assignments and projects that require independent research and study.

The curriculum includes a significant component of electives in the humanities and social sciences. ECE graduates will have knowledge of the broader contemporary issues that impact engineering solutions in a global and societal context. They will have the verbal and written communications skills necessary for a successful career in industry or academia. Graduates also understand the meaning and importance of professional and ethical responsibility.
Basic Program Requirements

Electrical Engineering Curriculum (128 hours)
Electrical & Computer Engineering Curriculum (128 hours)
Prerequisites, Co-requisites, and Terms Offered
Theory & Lab Course Schedule
Humanities and Social Sciences Requirements
Graduation Checklist
Miscellaneous Curriculum Notes
## Electrical Engineering Curriculum (128 hours)

### Math (19 hours) Minimum grade of C- required
- APPM 1350 Calculus 1 for Engineers 4
- APPM 1360 Calculus 2 for Engineers 4
- APPM 2350 Calculus 3 for Engineers 4
- APPM 2360 Diff Equations w/ Linear Algebra 4
- ECEN 3810 Probability** 3
***(May substitute APPM 3570 or MATH 4510 only)

### Physics (9 hours)
- PHYS 1110 General Physics 1 4
- PHYS 1120 General Physics 2 4
- PHYS 1140 Experimental Physics 1 1

### Freshman Elective (3-5 hours) choose one:
- ECEN 1400 Intro to Digital/Analog Elect. 3
- GEEN 1400 Freshman Projects 3
- Freshman Projects from other Engr. Dept. 3
- CHEM 1131 General Chemistry 2 (AP/transfer) 5

### Freshman Seminar (1 hour) choose one:
- ECEN 1100 Freshman Seminar 1
- GEEN 1500 Introduction to Engineering 1
- OR Freshman Seminar from other Engr. Dept. 1

### General Science Elective (3-5 hours) choose one:
- PHYS 2130 General Physics 3 3
- MCEN 3012 Thermodynamics 3
- CHEN 1211 General Chemistry for Engineers plus 3
- CHEM 1221 General Chemistry Lab 2
- EBIO 1210 General Biology 1 (lab optional) 3
- MCB 1150 Intro to Molecular Biology 3
- IPHY 3410 Intro to Human Anatomy 3

### Computer Programming (4 hours)
- ECEN 1310 C Programming for EE/ECE* 4
  *(May substitute CSCI 1300 for transfers only)

### Sophomore Electives (6 hours) choose two:
- ECEN 2410 Renewable Energy 3
- ECEN 2420 Electronics for Wireless Communication 3
- ECEN 2440 Application of Embedded Systems (also as ECEN 2020) 3
- ECEN 2--- Variable topic (see class schedule for title) 3

### Electrical Engineering Core (18 hours)
- ECEN 2250 Intro to Circuits & Electronics 3
- ECEN 2260 Circuits as Systems 3
- ECEN 2270 Electronics Design Lab 3
- ECEN 2350 Digital Logic 3
- ECEN 3350 Programming of Digital Systems 3
- ECEN 3360 Digital Design Lab 3

### Advanced Analog Core (9 hours)
- ECEN 3250 Microelectronics 3
- ECEN 3300 Linear Systems 3
- ECEN 3400 Fields 3

### Technical Electives Track Courses (12 hours)
- Must fulfill requirements for two "tracks" (see page 24)
  - ECEN 4011 Design of Implantable Devices (even yrs) 3
  - ECEN 4021 Engineering Apps in Medicine (odd yrs) 3
  - ECEN 4242 Communication Theory 3
  - ECEN 4652 Communication Lab 3
  - ECEN 4532 Digital Signal Processing Lab 3
  - ECEN 4632 Intro to Digital Filtering 3
  - ECEN 3410 EM Waves & Transmissions 3
  - ECEN 4634 Microwave/RF Lab 3
  - ECEN 3320 Semiconductor Devices 3
  - ECEN 4555 Prin of Energy Systems/Devices 3
  - ECEN 4015 Photovoltaic Devices (fall 2015) 3
  - ECEN 4606 Undergrad Optics Lab 3
  - ECEN 4616 Optoelectronic System Design 3
  - ECEN 4106 Photonics 3
  - ECEN 4116 Intro to Optical Communication 3
  - ECEN 3170 Electromagnetic Energy Conversion 1 3
  - ECEN 4167 Electromagnetic Energy Conversion 2 3
  - ECEN 4797 Intro to Power Electronics 3
  - ECEN 4517 Renewable Power Electronics Lab 3
  - ECEN 4138 Control Systems Analysis 3
  - ECEN 4638 Controls Lab 3

### Use other 3000/4000 technical courses in ECEN, other Engr departments, APPM/MATH, PHYS to complete 128 hour requirement. May also use 6 hrs EMEN/Business/ECON by petition. See rules on page 44. Check with Advisor for applicability.

### Capstone Design Lab (6 hours) Minimum grade of C- required
- ECEN 4610 Capstone Laboratory, Part 1 3
- ECEN 4620 Capstone Laboratory, Part 2 3

### Humanities/Social Sciences (21 hours)
- 1000/2000 A&S Core Lower Division 12
- 3000/4000 A&S Core Upper Division 6
- WRTG Approved upper-division writing 3

(see page 20 for course selection requirements)

### Free Electives (6 hours maximum)
- Student choice of courses

F = fall only
S = spring only
D=undergrad & grad
Sample Schedule for *Electrical Engineering Program*

**Freshman Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>APPM 1350</td>
<td>Calculus 1</td>
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<tr>
<td>PHYS 1110</td>
<td>Physics 1</td>
<td>4</td>
</tr>
<tr>
<td>ECEN 1100</td>
<td>Freshman Seminar</td>
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</tr>
<tr>
<td>ECEN 1400</td>
<td>Freshman Elective*</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Humanities &amp; Social Sciences</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL CREDIT HOURS</strong></td>
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**Sophomore Year**

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<tr>
<td>APPM 2360</td>
<td>Diff. Eq. with Linear Algebra</td>
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<tr>
<td>ECEN 24--</td>
<td>Sophomore Elective 1</td>
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</tr>
<tr>
<td>ECEN 2250</td>
<td>Intro to Circuits &amp; Electronics</td>
<td>3</td>
</tr>
<tr>
<td>ECEN 2350</td>
<td>Digital Logic</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Humanities &amp; Social Sciences</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL CREDIT HOURS</strong></td>
<td>16</td>
</tr>
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**Junior Year**

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<th>Hrs</th>
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<tbody>
<tr>
<td>ECEN 3350</td>
<td>Programming of Digital Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECEN 3810</td>
<td>Probability*</td>
<td>F</td>
</tr>
<tr>
<td>ECEN 3---</td>
<td>Advanced Analog Core</td>
<td>3</td>
</tr>
<tr>
<td>ECEN 3---</td>
<td>Advanced Analog Core</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Humanities &amp; Social Sciences</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL CREDIT HOURS</strong></td>
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**Senior Year**

<table>
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<tr>
<th>Course</th>
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<th>Hrs</th>
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<tbody>
<tr>
<td>ECEN 4610</td>
<td>Capstone Lab: Part 1</td>
<td>F</td>
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<tr>
<td></td>
<td>Technical Electives**</td>
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<tr>
<td></td>
<td>Humanities &amp; Social Sciences</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL CREDIT HOURS</strong></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Capstone Lab: Part 2</td>
<td>S</td>
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<tr>
<td></td>
<td>Technical Electives**</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Humanities &amp; Social Sciences</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL CREDIT HOURS</strong></td>
<td>15</td>
</tr>
</tbody>
</table>

Semester credit hours, General Science Elective hours, and Technical Elective hours may vary over semesters. Total hours taken towards the degree must equal 128. See page 16 for prerequisites for Capstone Lab 1 & 2.

* See the previous page for approved substitutes.

** See the previous page for General Science Electives and Technical Electives.

$F$ = course offered only in the fall semester; $S$ = course offered only in the spring semester
### Electrical & Computer Engineering Curriculum (128 hours)

**Math (19 hours)** Minimum grade of C- required

- **APPM 1350 Calculus 1 for Engineers** 4
- **APPM 1360 Calculus 2 for Engineers** 4
- **APPM 2350 Calculus 3 for Engineers** 4
- **APPM 2360 Diff Equations w/ Linear Algebra** 4
- **ECEN 3810 Probability** *(May substitute APPM 3570 or MATH 4510 only)*

**Physics (9 hours)**

- **PHYS 1110 General Physics 1** 4
- **PHYS 1120 General Physics 2** 4
- **PHYS 1140 Experimental Physics 1** 1

**Freshman Elective (3-5 hours) choose one:**

- **ECEN 1400 Intro to Digital/Analog Elect.** 3
- **CHEM 1131 General Chemistry 2** *(AP/transfer)* 5

**Freshman Seminar (1 hour) choose one:**

- **ECEN 1100 Freshman Seminar** 1
- **GEEN 1500 Introduction to Engineering** 1

**General Science Elective (3-5 hours) choose one:**

- **PHYS 2130 General Physics 3** 3
- **MCEN 3012 Thermodynamics** 3
- **CHEN 1211 General Chemistry for Engineers** 3
- **EBIO 1210 General Biology 1** *(lab optional)* 3
- **MCDB 1150 Intro to Molecular Biology** 3

**Computer Programming (4 hours)**

- **ECEN 1310 C Programming for EE/ECE** *(May substitute CSCI 1300 only for transfers)* 4

**Sophomore Electives (3 hours) choose one:**

- **ECEN 2410 Renewable Energy** *(also as ECEN 2060)* 3
- **ECEN 2420 Electronics for Wireless Communication** 3
- **ECEN 2440 Application of Embedded Systems** *(also as ECEN 2020)* 3
- **ECEN 2--- Variable topic** *(see class schedule for title)* 3

**Electrical Engineering Core (18 hours)**

- **ECEN 2250 Intro to Circuits & Electronics** 3
- **ECEN 2260 Circuits as Systems** 3
- **ECEN 2270 Electronics Design Lab** 3
- **ECEN 2350 Digital Logic** 3
- **ECEN 3350 Programming of Digital Systems** 3
- **ECEN 3360 Digital Design Lab** 3

**Computer Engineering Core (10 hours)**

- **ECEN 2703 Discrete Math for Computer Engineers** 3
- **CSCI 2270 Data Structures** 4
- **ECEN 4593 Computer Organization** 3

**Advanced Analog Core (6 hours) choose two:**

- **ECEN 3250 Microelectronics** 3
- **ECEN 3300 Linear Systems** 3
- **ECEN 3400 Fields** 3

**Humanities/Social Sciences (21 hours)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1000/2000</td>
<td>A&amp;S Core Lower Division</td>
<td>12</td>
</tr>
<tr>
<td>3000/4000</td>
<td>A&amp;S Core Upper Division</td>
<td>6</td>
</tr>
<tr>
<td>WRTG</td>
<td>Approved upper-division writing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Technical Electives (15-18 hours)

Must fulfill requirements for one “track” *(see page 24)*

**ECEN 4011** Design of Implantable Devices *(even yrs)* 3
**ECEN 4021** Engineering Apps in Medicine *(odd yrs)* 3
**ECEN 4242** Communication Theory 3
**ECEN 4652** Communication Lab 3
**ECEN 4532** Digital Signal Processing Lab 3
**ECEN 4632** Intro to Digital Filtering 3
**ECEN 3410** EM Waves & Transmissions 3
**ECEN 4634** Microwave/RF Lab 3
**ECEN 3320** Semiconductor Devices 3
**ECEN 4555** Prin of Energy Systems/Devices 3
**ECEN 4015** Photovoltaic Devices *(fall 2015)* 3
**ECEN 4606** Undergrad Optics Lab 3
**ECEN 4616** Optoelectronic System Design 3
**ECEN 4010** Photonics 3
**ECEN 4116** Intro to Optical Communication 3
**ECEN 4370** Electromagnetic Energy Conversion 1 3
**ECEN 4167** Electromagnetic Energy Conversion 2 3
**ECEN 4797** Intro to Power Electronics 3
**ECEN 4517** Renewable Power Electronics Lab 3
**ECEN 4138** Control Systems Analysis 3
**ECEN 4638** Controls Lab 3

Use other 3000/4000 technical courses in **ECEN**, other Engr departments, **APPM/MATH, PHYS** to complete 128 hour requirement. May also use 6 hrs **EMEN/Business/ECON** by petition. See rules on page 44. Check with Advisor for applicability.

### Non-track Technical Electives

- **ECEN 4593** Computer Organization 3
- **ECEN 4613** Embedded System Design 3
- **ECEN 4623** Real-Time Digital Embedded Systems 3
- **ECEN 4653** Real-Time Digital Media Systems 3
- **ECEN 4224** High-Speed Digital Design 3
- **ECEN 4324** Fund of Microsystem Packaging 3
- **ECEN 4---** Selected Special Topics 3

### Software Electives (3-4 hours) choose one:

- **ECEN 4553** Compiler Construction *(even years)* 3
- **ECEN 4583** Software Systems Development 3
- **CSCI 3202** Intro to Artificial Intelligence 3
- **CSCI 3287** Database & Information Systems 3
- **CSCI 3308** Software Engr Methods & Tools 3
- **CSCI 3753** Operating Systems 4
- **CSCI 4113** Unix Systems Administration 3
- **CSCI 4229** Computer Graphics 3
- **CSCI 4273** Network Systems 3
- **CSCI 4838** User Interface Design 3

### Capstone Design Lab (6 hours) Minimum grade of C- required

- **ECEN 4610** Capstone Laboratory, Part 1 3
- **ECEN 4620** Capstone Laboratory, Part 2 3

### Free Electives (6 hours maximum)

Student choice of courses

- **F** = fall only
- **S** = spring only
- **D** = undergrad & grad
Sample Schedule for Electrical & Computer Engineering Program

### Freshman Year

#### Fall

<table>
<thead>
<tr>
<th>Course</th>
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<th>Hrs</th>
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<tbody>
<tr>
<td>APPM 1350</td>
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<tr>
<td>PHYS 1110</td>
<td>Physics 1</td>
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<tr>
<td>ECEN 1100</td>
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<td>ECEN 1400</td>
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<td>PHYS 1120</td>
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<td>PHYS 1140</td>
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### Sophomore Year

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<tr>
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<td>ECEN 24--</td>
<td>Sophomore Elective</td>
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<td>ECEN 2250</td>
<td>Intro to Circuits &amp; Electronics</td>
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<td>ECEN 2703</td>
<td>Discrete Mathematics $^F$</td>
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<td>Digital Logic</td>
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<td>ECEN 2260</td>
<td>Circuits as Systems</td>
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<td>ECEN 2270</td>
<td>Electronics Design Lab</td>
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### Junior Year

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<td>Programming of Digital Systems</td>
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<tr>
<td>ECEN 3810</td>
<td>Probability* $^F$</td>
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<td>ECEN 3---</td>
<td>Advanced Analog Core</td>
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<td>CSCI 2270</td>
<td>Data Structures</td>
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<td>Digital Design Lab</td>
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<tr>
<td>ECEN 3---</td>
<td>Advanced Analog Core</td>
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### Senior Year

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<td>Humanities &amp; Social Sciences</td>
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<td>Free Elective</td>
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#### Spring

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<td>ECEN 4620</td>
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<td>ECEN 4593</td>
<td>Computer Organization</td>
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<td>Humanities &amp; Social Sciences</td>
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<tr>
<td>Free Elective</td>
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<tr>
<td><strong>TOTAL CREDIT HOURS</strong></td>
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</table>

Semester credit hours, General Science Elective hours, and Technical Elective hours may vary over semesters. Total hours taken towards the degree must equal 128. See page 16 for prerequisites for Capstone Lab 1 & 2

* See the previous page for approved substitutes.

** See the previous page for General Science Electives and Technical Electives.

$^F$ = course offered only in the fall semester; $^S$ = course offered only in the spring semester
### Prerequisites, Co-requisites, and Terms Offered

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Prerequisites and Co-requisites</th>
<th>Term offered</th>
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<td><strong>General Courses</strong></td>
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<td>1310</td>
<td>C Programming for ECE (was 1030)</td>
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<td>1400</td>
<td>Intro to Digital &amp; Analog Electronics</td>
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<td>Circuits as Systems</td>
<td>ECEN 2250</td>
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<td>ECEN 1310, ECEN 2260 (co-req)</td>
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<td>2350</td>
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<td>Discrete Mathematics</td>
<td>ECEN 1310 or CSCI 1300, APPM 1360</td>
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<td>3250</td>
<td>Microelectronics</td>
<td>ECEN 2260</td>
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<td>3300</td>
<td>Linear Systems</td>
<td>ECEN 2260</td>
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<td>Programming Digital Systems</td>
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<td>Digital Design Lab</td>
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<td>APPM 2350, ECEN 2250, PHYS 1110</td>
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<td>3810</td>
<td>Introduction to Probability</td>
<td>APPM 2350</td>
<td>Fall</td>
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<td>ECEN 2270, 3360, final Advanced Analog Electives concurrent</td>
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<td>4620</td>
<td>Capstone Laboratory 2</td>
<td>ECEN 4610 &amp; 2 (ECE) or 3 (EE) Advanced Analog Electives</td>
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<td><strong>Biomedical and Engineering</strong></td>
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<td>4/5011</td>
<td>Design of Implantable Devices</td>
<td>ECEN 2260</td>
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<td>4/5021</td>
<td>Engineering Applications in Medicine</td>
<td>ECEN 2260</td>
<td>Spring odd yrs</td>
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<td><strong>Communication and Signal Processing</strong></td>
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<td>Communication Theory</td>
<td>ECEN 3300, 3810</td>
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<td>4/5532</td>
<td>DSP Laboratory</td>
<td>ECEN 3300, 4632</td>
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<td>4632</td>
<td>Introduction to Digital Filtering</td>
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<td>4652</td>
<td>Communication Laboratory</td>
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<td>4593</td>
<td>Computer Organization</td>
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<td>4/5613</td>
<td>Embedded Systems Design</td>
<td>ECEN 3360 (3250, 4593 recommended)</td>
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<td>4/5623</td>
<td>Real-Time Embedded Systems</td>
<td>ECEN 3360 (4613 recommended)</td>
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<td>4/5643</td>
<td>SW Engineering of Concurrent Systems</td>
<td>ECEN 4583 or 5543</td>
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<tr>
<td>4/5653</td>
<td>Real-Time Digital Media</td>
<td>ECEN 1310, CSCI 3753 (see catalog for prereqs)</td>
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<td>4/5743</td>
<td>SW Engineering of Distributed Systems</td>
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<td>4138</td>
<td>Control Systems Analysis</td>
<td>ECEN 3300</td>
<td>Fall</td>
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<tr>
<td>4638</td>
<td>Control Systems Laboratory</td>
<td>ECEN 4138</td>
<td>Spring</td>
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<tr>
<td><strong>Electromagnetics, RF, and Microwaves</strong></td>
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<tr>
<td>2420</td>
<td>Electronics for Wireless Communication</td>
<td>PHYS 1120, APPM 1360, ECEN 2250 pre/coreq</td>
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<tr>
<td>3410</td>
<td>Electromagnetic Waves &amp; Transmission</td>
<td>ECEN 3400</td>
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<td>4/5224</td>
<td>High Speed Digital Design</td>
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<td>Microsystem Packaging</td>
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<td>Microwave &amp; RF Lab</td>
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<td>4xx5</td>
<td>Photovoltaic Devices</td>
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<td>Principles of Electrical Energy Systems</td>
<td>ECEN 3810, PHYS 2130 or 2170 (co-req)</td>
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<td>Optoelectronic System Design</td>
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### Prerequisites, Co-requisites, and Terms Offered

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<td>Renewable Power Electronics Lab</td>
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<td>Introduction to Power Electronics</td>
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Minimum grade required for all prerequisite courses is C-.

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### Miscellaneous Curriculum Notes

The curricula listings on page 12 and page 14 are not a misprint. It is necessary that you take APPM 2360 (Differential Equations with Linear Algebra) before APPM 2350 (Calculus 3). Material covered in APPM 2360 will help you with ECEN 2250 and must be taken as a co-requisite if not taken prior to 2250.

Because the curriculum is in transition, the numbers associated with the core courses may change. The course titles, however, should remain the same. Always check the schedule for the upcoming semester on the web page at http://ecee.colorado.edu.

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### Other Important Publications and Links

- **University of Colorado Catalog**
  Degree requirements, academic standards, administrative regulations, university policies and procedures (dry and dull, but important)
  [http://www.colorado.edu/catalog/](http://www.colorado.edu/catalog/)

- **College Information**
  College of Engineering requirements, rules, regulations (must read).
  [http://www.colorado.edu/engineering/](http://www.colorado.edu/engineering/)

- **Ralphie’s Guide to Student Life**
  A-Z listing of university resources, facilities, and special programs as well as rules, regulations, and policies
  [http://www.colorado.edu/ralphie/](http://www.colorado.edu/ralphie/)

- **Registrar’s Office**
  Deadlines, instructions for registration and drop/add, transcript requests, calendars
  [http://registrar.colorado.edu](http://registrar.colorado.edu)
## Prerequisites for ECEE Program Courses

| Prerequisite courses | APM 1350 | APM 1360 | APM 2350 | APM 2360 | PHYS 1210 | PHYS 2270 | ECEN 1410 | ECEN 1490 | ECEN 1610 | ECEN 2350 | ECEN 2360 | ECEN 2370 | ECEN 2380 | ECEN 2390 | ECEN 2400 | ECEN 2410 | ECEN 2420 | ECEN 2430 | ECEN 2450 | ECEN 2460 | ECEN 2470 | ECEN 2480 | ECEN 2490 | ECEN 2500 | ECEN 2510 | ECEN 2520 | ECEN 2530 | ECEN 2540 | ECEN 2550 | ECEN 2560 | ECEN 2570 | ECEN 2580 | ECEN 2590 | ECEN 2600 | ECEN 2610 | ECEN 2620 | ECEN 2630 | ECEN 2640 | ECEN 2650 | ECEN 2660 | ECEN 2670 | ECEN 2680 | ECEN 2690 | ECEN 2700 | ECEN 2710 | ECEN 2720 | ECEN 2730 | ECEN 2740 | ECEN 2750 | ECEN 2760 | ECEN 2770 | ECEN 2780 | ECEN 2790 | ECEN 2800 | ECEN 2810 | ECEN 2820 | ECEN 2830 | ECEN 2840 | ECEN 2850 | ECEN 2860 | ECEN 2870 | ECEN 2880 | ECEN 2890 | ECEN 2900 | ECEN 2910 | ECEN 2920 | ECEN 2930 | ECEN 2940 | ECEN 2950 | ECEN 2960 | ECEN 2970 | ECEN 2980 | ECEN 2990 | ECEN 3100 | ECEN 3110 | ECEN 3120 | ECEN 3130 | ECEN 3140 | ECEN 3150 | ECEN 3160 | ECEN 3170 | ECEN 3180 | ECEN 3190 | ECEN 3200 | ECEN 3210 | ECEN 3220 | ECEN 3230 | ECEN 3240 | ECEN 3250 | ECEN 3260 | ECEN 3270 | ECEN 3280 | ECEN 3290 | ECEN 3300 | ECEN 3310 | ECEN 3320 | ECEN 3330 | ECEN 3340 | ECEN 3350 | ECEN 3360 | ECEN 3370 | ECEN 3380 | ECEN 3390 | ECEN 3400 | ECEN 3410 | ECEN 3420 | ECEN 3430 | ECEN 3440 | ECEN 3450 | ECEN 3460 | ECEN 3470 | ECEN 3480 | ECEN 3490 | ECEN 3500 | ECEN 3510 | ECEN 3520 | ECEN 3530 | ECEN 3540 | ECEN 3550 | ECEN 3560 | ECEN 3570 | ECEN 3580 | ECEN 3590 | ECEN 3600 | ECEN 3610 | ECEN 3620 | ECEN 3630 | ECEN 3640 | ECEN 3650 | ECEN 3660 | ECEN 3670 | ECEN 3680 | ECEN 3690 | ECEN 3700 | ECEN 3710 | ECEN 3720 | ECEN 3730 | ECEN 3740 | ECEN 3750 | ECEN 3760 | ECEN 3770 | ECEN 3780 | ECEN 3790 | ECEN 3800 | ECEN 3810 | ECEN 3820 | ECEN 3830 | ECEN 3840 | ECEN 3850 | ECEN 3860 | ECEN 3870 | ECEN 3880 | ECEN 3890 | ECEN 3900 | ECEN 3910 | ECEN 3920 | ECEN 3930 | ECEN 3940 | ECEN 3950 | ECEN 3960 | ECEN 3970 | ECEN 3980 | ECEN 3990 | ECEN 4000 | ECEN 4010 | ECEN 4020 | ECEN 4030 | ECEN 4040 | ECEN 4050 | ECEN 4060 | ECEN 4070 | ECEN 4080 | ECEN 4090 | ECEN 4100 | ECEN 4110 | ECEN 4120 | ECEN 4130 | ECEN 4140 | ECEN 4150 | ECEN 4160 | ECEN 4170 | ECEN 4180 | ECEN 4190 | ECEN 4200 | ECEN 4210 | ECEN 4220 | ECEN 4230 | ECEN 4240 | ECEN 4250 | ECEN 4260 | ECEN 4270 | ECEN 4280 | ECEN 4290 | ECEN 4300 | ECEN 4310 | ECEN 4320 | ECEN 4330 | ECEN 4340 | ECEN 4350 | ECEN 4360 | ECEN 4370 | ECEN 4380 | ECEN 4390 | ECEN 4400 | ECEN 4410 | ECEN 4420 | ECEN 4430 | ECEN 4440 | ECEN 4450 | ECEN 4460 | ECEN 4470 | ECEN 4480 | ECEN 4490 | ECEN 4500 | ECEN 4510 | ECEN 4520 | ECEN 4530 | ECEN 4540 | ECEN 4550 | ECEN 4560 | ECEN 4570 | ECEN 4580 | ECEN 4590 | ECEN 4600 | ECEN 4610 | ECEN 4620 | ECEN 4630 | ECEN 4640 | ECEN 4650 | ECEN 4660 | ECEN 4670 | ECEN 4680 | ECEN 4690 | ECEN 4700 | ECEN 4710 | ECEN 4720 | ECEN 4730 | ECEN 4740 | ECEN 4750 | ECEN 4760 | ECEN 4770 | ECEN 4780 | ECEN 4790 | ECEN 4800 | ECEN 4810 | ECEN 4820 | ECEN 4830 | ECEN 4840 | ECEN 4850 | ECEN 4860 | ECEN 4870 | ECEN 4880 | ECEN 4890 | ECEN 4900 | ECEN 4910 | ECEN 4920 | ECEN 4930 | ECEN 4940 | ECEN 4950 | ECEN 4960 | ECEN 4970 | ECEN 4980 | ECEN 4990 |
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Biomedical Engineering
ECEN 4011 Design of Implantable Medical Devices (spring even yrs)
  Prerequisite: ECEN 2260 Circuits as Systems
ECEN 4021 Engineering Applications in Medicine (spring odd yrs)
  Prerequisite: ECEN 2260 Circuits as Systems

Communication
ECEN 4242 Communication Theory (fall)
  Prerequisites: ECEN 3300 Linear Systems and ECEN 3810 Probability or approved substitute
ECEN 4652 Communication Lab (spring)
  Prerequisite: ECEN 4242 Communication Theory

Digital Signal Processing
ECEN 4632 Intro to Digital Filtering (fall)
  Prerequisite: ECEN 3300 Linear Systems
ECEN 4532 Digital Signal Processing (DSP) Lab (spring)
  Prerequisite: ECEN 4632 Intro to Digital Filtering

Dynamics & Controls
ECEN 4138 Control Systems Analysis
  Prerequisite: ECEN 3300 Linear Systems
ECEN 4638 Controls Lab
  Prerequisite: ECEN 4138 Control Systems Analysis

Electromagnetics, RF & Microwaves
ECEN 3410 Electromagnetic Waves & Transmission (spring)
  Prerequisite: ECEN 3400 Electromagnetic Fields & Waves
ECEN 4634 Microwave/RF Lab (fall)
  Prerequisite: ECEN 3410 EM Waves & Transmission

Nanostructure Materials & Devices
ECEN 4555 Principles of Energy Systems & Devices (fall)
  Prerequisite: Probability and PHYS 2130 or 2170
ECEN 3320 Semiconductor Devices (spring)
  Prerequisite: ECEN 3250 Microelectronics
ECEN 4XX5 Photovoltaic Devices (beginning fall 2015)
  Prerequisite: ECEN 3250 Microelectronics

Optics & Photonics
ECEN 4616 Optoelectronic System Design (spring)
  Prerequisite: ECEN 3400 Electromagnetic Fields & Waves
ECEN 4606 Undergraduate Optics Lab (spring 2015)
  Prerequisite: ECEN 3400 Electromagnetic Fields & Waves

Power Electronics
ECEN 4797 Intro to Power Electronics (fall)
  Prerequisite: ECEN 3250 Microelectronics
ECEN 4517 Renewable Power Electronics Lab (spring)
  Prerequisite: ECEN 4797 Intro to Power Electronics

Renewable Energy
ECEN 3170 Electromagnetic Energy Conversion 1 (fall)
  Prerequisite: ECEN 2260 Circuits as Systems
ECEN 4167 Electromagnetic Energy Conversion 2 (spring)
  Prerequisite: ECEN 3170 Electromagnetic Energy Conversion 1
Humanities and Social Sciences Requirements

Students must complete 18 credit hours in approved courses in the Humanities and Social Sciences and 3 credit hours in an approved upper division writing course. These courses are all included in the 21 hours required for Humanities & Social Sciences in the online degree audit in mycuinfo.

Writing: 3 credit hours in one of the following courses: HUEN 1010 (for first year freshmen only), WRTG 3030, WRTG 3035, HUEN 3100. Upper-division transfer courses may be approved by petition.

H&SS: 18 credit hours of approved courses, of which 6 must be at the 3000 level or higher.

Courses approved for the 18 credit-hour H&SS requirement:

• Any course included in the following acceptable categories of courses in the Arts &Sciences Core found from the A&S Core Curriculum web page and through the Search for Courses in mycuinfo registration tab:
  a) Contemporary Societies
  b) Culture & Gender Diversity
  c) Foreign Language
  d) Historical Context
  e) Ideals and Values
  f) Literature and the Arts
  g) United States Context

• See http://colorado.edu/engineering/academics/policies/hss for assistance in selecting approved courses. Any exceptions must be approved by petition to the department and college. Also see “Quick Humanities Search Instructions” found at http://ecee.colorado.edu/academics/ugrad/overview.html.

• Approval is granted for any group of four courses that would count toward a minor field in any of the following departments in the College of Arts and Sciences: Economics, Ethnic Studies, History, Linguistics, Philosophy, Political Science, Religious Studies, or Women’s Studies. (Note: These courses are approved for H&SS credit only if taken as a group of four courses that would count toward a minor field.) For further information on minor fields, see www.colorado.edu/ArtsSciences/students/undergraduates/minors.html.

• All courses taught through the Herbst Program of Humanities for Engineers and have “HUEN” as their prefix are approved. See the description of the Herbst Program below.

Herbst Program for Humanities

The centerpiece of the Herbst Program is a two-semester seminar sequence open to Juniors and Seniors. These seminars are limited to 12 students and are devoted to roundtable discussions of original texts, primarily in literature and philosophy, but with secondary attention to art, music, and architecture. These seminars also help our students improve their writing skills, gain confidence and skill in civil discourse on controversial issues, see more clearly the inadequacy of dogmatic responses to complex questions, and develop intellectual rigor on non-technical issues. Students must apply to participate in the Junior Seminars, which also satisfy the University’s required writing course.

The Herbst Program also offers courses at other levels. HUEN 1010 is similar to HUEN 3100 in being a text-based seminar, but it is designed for freshmen. In HUEN 1100, History of Science & Technology, original source material and textbook readings provide insight into science and technology in changing historical, social, and political contexts. For Freshmen and Sophomores, Herbst offers Tradition and Identity, HUEN 2010, which explores the following questions: Why am I who I am, and why do I desire my future to look a certain way? What ways, both positively and negatively, does tradition determine/influence the possibilities of my individuality?

For a full list of courses and other information, see http://engineering.colorado.edu/herbst/
Graduation Checklist

☐ 1. Successfully complete a minimum of 128 semester credit hours according to the curriculum in effect at the
time the student was officially admitted to the EEEN or ECEN degree program. The last 45 credit hours must
be earned as a degree student in classes at the Boulder campus after admission to the College of Engineering
and Applied Science unless exempted by prior petition.

☐ 2. Achieve a cumulative grade point average of 2.25 or better in all courses taken at the University of Colorado
(all campuses) as well as a grade point average of 2.25 or better in all courses taken from, or cross listed in,
the Department of Electrical, Computer, and Energy Engineering.

☐ 3. Satisfy any outstanding MAPS deficiencies. These deficiencies should have been resolved in the first year or
two of enrollment in the College, but students cannot graduate without having met the basic requirements in
effect at the time of their admission.

☐ 4. Meet with the Undergraduate Staff Advisor the semester prior to the semester of intended graduation for a
comprehensive review and approval of remaining courses needed to satisfy graduation requirements.

☐ 5. Complete the Application for Graduation online using mycuinfo. Deadlines for completion of the application
process will be announced by the Registrar’s Office, the Engineering Dean and the Undergraduate Staff Advisor.

☐ 6. If you are completing a minor, a Minor Completion form must be submitted to the Undergraduate Staff Advisor’s Office prior to graduation.

☐ 7. A graduation list is posted near the ECEE Undergraduate Advisor’s Office (EE 1B20) about a month after the
beginning of each semester. Students intending to graduate should make certain that their names are listed.
Any omissions or changes should be reported to the ECEE Undergraduate Advisor as soon as possible.

*It is the responsibility of each student to be certain that all degree requirements have been met and to keep the Department informed of any change in graduation plans.*
ECEN Track Courses

Choosing Theory and Elective Track Courses
Communications
Digital Signal Processing
Dynamics And Controls
Electromagnetics, RF And Microwaves
Nanostructure Materials & Devices
Neural And Biomedical Engineering
Optics and Photonics
Power Electronics
Renewable Energy
Choosing Theory and Elective Track Courses

The body of knowledge found under Electrical, Computer, and Energy Engineering is far too large to be obtained in only four years of college. Because of the continual appearance of new technologies, new tools, and new opportunities, this body of knowledge gets ever larger. This situation is not a matter of concern, but it is merely the inevitable consequence of healthy growth in the profession.

As a student of the profession, you need to have a combination of broad and narrow studies. All Electrical Engineers share a special vocabulary and a core knowledge of things electrical. But because the range of application is so large, it is necessary for you to sample some areas of specialization. This section has been prepared to help you select upper division courses in areas of interest (tracks) in which you might eventually specialize. The areas chosen reflect the individual research interests and expertise of our faculty. Faculty members in each area have written the one-page descriptions.

Each track lists prerequisite courses (normally from the ECEE core) and the courses that must be taken to complete the track. As part of the curriculum requirements, EE majors must complete at least two tracks, while ECE majors must complete at least one track.

Should you develop an appetite for further study, or would like to be involved in some independent work, you should consult one or more of the faculty listed. Faculty contact information is available on page 48 and also on the ECEE web site.

Finally, be sure to consult the current University Course Catalog or the Course Schedule (found on a link from the front page of the department’s site) for course descriptions. Several of the areas have listed follow-on graduate courses for those interested in further study.
Communications

Core prerequisite: Linear Systems, ECEN 3300
ECEN 4242 - Communication Theory
ECEN 4652 - Communication Lab

Faculty advisors: E. Liu, P. Mathys, M. Varanasi

One of the most fascinating and important topics in electrical communications is the wireless transmission and reception of analog and digital signals. Early examples, most of which are still in use today, include wireless communication using Morse signals and AM (amplitude modulation) and FM (frequency modulation) radio broadcasts. Modern examples of wireless systems are satellite radio and TV, wireless LANs (local area networks), and cellular telephones.

All practical communication systems are affected by noise that is picked up during transmission, either by the communication channel itself or by the front-end of the receiver, and the signal-to-noise ratio (SNR) of the received signal is a crucial measure for the quality of a communication system. For analog systems quality is synonymous with high fidelity reproduction of the transmitted signal. For digital systems the main quality measure is the probability of bit or symbol error. Early on, the common perception was that in order to improve quality more transmit power was needed. But it is now recognized that putting intelligence in various forms of coding into communication systems is an energy-conscious and smart alternative. Most modern communication systems use digital symbols to represent signals, independent of whether the original signal, like speech or music, is analog or, like computer data, is already digital. Source coding, like MP3, for example, and error-control coding can be applied easily to digitally represented signals. However, most physical channels require a waveform that is continuous in time and in amplitude and is restricted to a specific frequency range for efficient signal transmission. Thus, important topics for the treatment of communication systems are the study of signal processing of both analog and digital signals and the conversion between analog and digital representations.

Representative Technical Applications
- Wireless and wired transmission of analog and digital data
- Reliable reception of analog and digital data
- Information storage and retrieval
- Telephone network, cell phones, data networks
- Coding for compression, error-control, and secrecy/privacy
- Radio and TV broadcasts

Representative Societal Applications
- Voice and data communication for personal and commercial purposes
- Digital storage of multimedia including audio, images, and movies
- Wireless communication networks for remote areas
- Communications for rescue missions and disaster recovery
Digital Signal Processing

Core prerequisite: Linear Systems, ECEN 3300
ECEN 4632 – Digital Filtering
ECEN 4532 – Digital Signal Processing Laboratory

Faculty advisors: S. Hughes, F. Meyer

Digital Signal Processing became possible when digital computers came into existence and then became cheap enough to be considered components. Almost all the classical analog signal processing applications (like telephones, radio sets, signal generators, and oscilloscopes) can now be done digitally. DSP is done in real time or offline; it is done on one-dimensional signals like audio, and two-dimensional signals like images. Embedded processors for doing DSP are found in cell phones, audio players, digital cameras, automobile engines, braking control systems, and medical instruments. Examples of applications on large computers include seismic exploration, geophysical mapping, motion picture animation, and medical imaging. The range of application is enormous.

To study Digital Signal Processing, it is necessary to have a good grounding in discrete-time linear systems and time-frequency transformations. The essential pre-requisite for the senior DSP theory and lab courses is the Linear Systems Core course. In addition, real-time applications require experience with assembly language code development. Offline processing requires the use of high-level application languages like MATLAB. DSP is a good area for those who enjoy the design and development of algorithms, applied mathematics, and applications. Students who intend to complete degrees in both EE and Music will find the DSP lab course especially interesting.

Representative Technical Applications
- Audio generation, coding, reproduction, and enhancement
- Image Processing, enhancement, coding, and pattern recognition
- Video analysis, coding and decoding
- Wireless Communications modulation and demodulation
- The Design of dedicated DSP processors
- The use of DSP in feedback control

Representative Societal Applications
- Aids for human speech and hearing
- Aids for human vision
- Medical instruments which can see into the body and the brain
- Environmental analysis using remote sensing data
Dynamics And Controls

Core prerequisite: Linear Systems, ECEN 3300
ECEN 4138 – Control Systems Analysis
ECEN 4638 – Control Systems Laboratory

Faculty advisors: J. Hauser, J. Marden, D. Meyer, L. Pao

Safe airplanes and vehicles, minimally invasive surgery, reliable manufacturing, computer-assisted physical rehabilitation—these all have automatic control and robotics as core technologies. Automatic control has been a key technological component since the middle of the 20th century, and with the advent of fast computers, nearly any device that moves or has dynamics has an embedded digital controller. Moreover, robotic applications have found their way into more than just automotive manufacturing. We now see robotic devices in medical, defense, and renewable power industries. Students wishing to pursue these areas will increasingly need expertise in the robotics and control areas.

To study robotics and control, students need to have taken Linear Systems Analysis (ECEN 3300) and the controls sequence early. If possible, students should take ECEN 3300 by their Spring junior term so that they can take ECEN 4138/4638 in their Fall/spring senior term. This will allow them to take a senior robotics elective. Many students find that a course in matrix methods (typically offered through the Applied Mathematics Department) is helpful in robotics and control. Other relevant courses include embedded systems and power electronics, both of which play significant roles in autonomous, robotic systems.

Representative Technical Applications
• Haptic rendering for minimally-invasive surgery
• Motion planning in uncertain environments, such as the NASA Mars rover
• Flight control of aggressive aircraft
• Reconfigurable manufacturing
• Image recognition and autonomous response
• Fast and precise control of atomic force & near field scanning optical microscopes

Representative Societal Applications
• Safe transportation
• Precise medical treatment and rehabilitation
• Efficient energy usage
Electromagnetics, RF And Microwaves

Core prerequisite: Electromagnetic Fields, ECEN 3400
ECEN 3410 – Electromagnetic Waves and Transmission
ECEN 4634 – RF & Microwave Laboratory

Faculty advisors: D. Filipovic, A. Gasiewski, E. Kuester, M. Piket-May, Z. Popovic

The origins of electromagnetics can be traced to the earliest days of human existence. Fear and fascination with many natural phenomena including lightning lingered for thousands of years until sound physical understandings were developed. Ancient Greeks noticed that rubbing fur against amber (‘electron’ in Greek language) caused attraction between the two. The 20th century archeological findings indicate that the first battery was made in old Iraq in 3rd century BC. Many scientists and free thinking minds over the last 300 years, including Benjamin Franklin, Michael Faraday, Nikola Tesla, James Clerk Maxwell, Heinrich Hertz and others have contributed to tremendous advances in electromagnetics, and by application of electromagnetics, to electrical and electronic engineering as a whole. Try to imagine life without electrical signals, power, and modern electronic materials: radio, TV, phones, air travel, refrigeration, etc... would be virtually impossible.

The CU Electromagnetics, RF and Microwave focus area provides the necessary foundation for understanding the phenomena of electricity, magnetism and radio waves, and facilitates the engineering of a wide range of RF and microwave components, devices, sub-systems, and systems. EM theory, design, measurements and fabrication are covered on a level that enables a career in industry, government, or further education on a master or doctoral level. A background in mathematics and elementary circuits are needed. The low-frequency part of this track is the foundation for circuit theory, while the high-frequency portion merges with the optics track.

Representative Technical Applications
• Generation, transmission, propagation, and reception of radio waves
• Wireless, satellite, and cable communications, including radio and television
• Antennas for cell phones, vehicles, space exploration, navigation, and sensing
• RF and microwave transmitters and receivers
• Microwave transmission lines, amplifiers, oscillators, resonators, and filters
• Radar, concealed weapon and buried object detection; stealth design
• Remote sensing of Earth and planetary surfaces, oceans, atmospheres, and cryospheres
• RF tagging, telemetry, therapeutic and industrial heating
• Acoustic sensing and communications; seismic sensing

Representative Societal Applications
• Wireless communications and networking
• Medical instrumentation, diagnostics, treatment and therapeutics
• Alternative energy resources – wireless power harvesting
• Environment sensing, monitoring, and forecasting
• Border control, defense, homeland security

Possible follow-on courses
ECEN 5114, Waveguides and Transmission Lines
ECEN 5134, Electromagnetic Radiation and Antennas
ECEN 5104, Computer-Aided Microwave Circuit Design
ECEN 5254, Radar and Remote Sensing
Nanostructure Materials & Devices

Prerequisites: Microelectronics, ECEN 3250 (Modern Physics PHYS 2130 recommended)
(chose two of 3 courses to complete the track)
ECEN 3320 – Semiconductor Devices
ECEN 4555 – Principles of Energy Systems & Devices (requires PHYS 2130 but not ECEN 3250)
ECEN 4xx5 – Photovoltaic Devices (temporary catalog number) available beginning fall 2015

Faculty advisors: J. Gopinath, G. Moddel, W. Park, S. Shaheen, B. Van Zeghbroeck

Materials and device electronics dominated technological advances in the 20th century, and are advancing at an accelerated rate in the 21st century. Early electronics used the vacuum tube, but about 50 years ago this gave way to solid state electronics based on semiconductors. This enabled the growth of the microelectronics industry, integrated circuits, superconductor devices, and more recently practical use of solar cells. Virtually all audio, video, communications, computing and more recently aerospace and automotive technologies are based on microelectronic devices. During the last few years, nanostructured materials and nano-scale (below 1 micron) devices have allowed the fabrication of devices that were not even dreamed of earlier.

Nanostructures is based upon a solid understanding of modern physics as well as a “feel” for physical structures. In addition to the physics courses required for the EE degree, it would be useful to take PHYS 2130 Modern Physics as early as possible. The stepping-off point to junior and senior-level nanostructures courses is ECEN 3250 Microelectronics. ECEN 3320 Semiconductor Devices, ECEN 4555 Principles of Energy Systems & Devices (ECEN 3250 not required), and ECEN 4XX5 Photovoltaic Devices can be taken in any order. Semiconductor Devices and Photovoltaic Devices use underlying physics to develop an understanding of electronics and solar cell technology. Principles of Energy Systems & Devices develops thermodynamics concepts to explore energy technologies.

Representative Technical Applications
- Lower-power portable devices
- Lasers and solid-state lighting devices
- Flat-panel displays
- Solar cells
- Energy conversion devices and systems
- Higher-density computers and memories
- Digital cameras and photodetectors

Representative Societal Applications
- Alternative energy devices
- Internet, communications and entertainment
- Nano-scale electronic devices for medical implants
- Medical imaging, cancer detection and therapeutics
**Neural And Biomedical Engineering**

*Core prerequisite:* Circuits as Systems, ECEN 2260  
(take 2 of 3 listed below)  
ECEN 4011 – Design of Implantable Medical Devices  
ECEN 4021 – Engineering Applications in Medicine  
ECEN 4053 – Assistive Technologies for People with Disabilities

**Faculty advisors: M. Lightner, R. Mihran**

The roots of electrical engineering and neuroscience both go back to the late 18th century when scientific debates as to the fundamental nature of electricity and its role in the neural control of muscle activity were raging. For example, the Italian physiologist and anatomist Luigi Galvani built a sensitive device (subsequently known as a Galvanometer) used it to, he claimed, detect electrical activity in active frog muscles. His fellow Italian, physicist Alessandro Volta, however, disputed this and suggested instead that the electrical potentials (subsequently known as Voltages) that Galvani registered were due to the interface of metal wires with the muscle tissue. To prove his point Volta showed that you could generate voltages simply by interfacing metal plates with salt solutions—and in so doing he invented the battery! History would prove that both Galvani and Volta were correct in their own context and ever since progress in electrical and neural sciences has been intrinsically linked.

Today, this strong linkage between ECE and Neural Sciences has re-emerged as a field called Neural Engineering or Neurotechnology, and it is well represented in the course offerings open to junior and senior (as well as first-year graduate) EE/ECE students.

The NE track does not require any previous coursework in biology. The courses listed above are designed to be comprehensible to engineering students with no prior biological background.

**Representative Technical Applications**

- Measurements of biomedically important signals  
- Algorhythms for biomedical signal processing and display  
- Technologies for imaging body anatomy (MRI, CAT, etc.) and imaging neuroelectric activity patterns (FMRI, etc.)  
- Studying the molecular and cellular basis of bioelectrical phenomena  
- Applying control theory and signal flow concepts to physiological systems  
- Quantifying and understanding the biological effects of electromagnetic fields  
- Modeling the genesis and propagation of neuromagnetic fields  
- Improving neurosurgical techniques such as Deep Brain Stimulation

**Representative Societal Applications**

- Improved diagnoses and treatment for cardiac, vascular, and pulmonary diseases.  
- Improved diagnoses and treatment for neural diseases.  
- Development of assistive devices for cognitive disabilities  
- Development of brain controlled prostheses for disabled patients.  
- Better understanding of health risks (or lack thereof) posed by EMF devices.  
- Refinement of "artificial intelligence" to be more like actual cognitive function.
Optics and Photonics

Core prerequisite: Electromagnetic Fields and Waves, ECEN 3400 and Linear Systems, ECEN 3300
ECEN 4606 - Undergraduate Optics Lab
ECEN 4616 - Optoelectronic System Design

Faculty advisors: J. Gopinath, R. McLeod, A. Mickelson, R. Piestun, M. Popovic, K. Wagner

From LCD displays and CMOS cameras, fiber optics and telecommunications, to medical and astronomical imaging, optics and photonics are critical to many modern technologies. Based on the science of light, optics and photonics are at the confluence of electrical and optical engineering with applied physics. Iconic developments that are prevalent in daily life such as the laser, holography, liquid crystal displays, charge coupled device (CCD) detectors, and fiber optics are being extended by CU faculty into future applications such as silicon photonics, computational imaging, nano-lithography, biophotonics, femtosecond lasers, and quantum and optical computing.

The study of Optics and Photonics requires a background in electromagnetic fields and waves and the interaction of light with matter, as well as the system viewpoint of linear systems and communication theory. Thus, both fields and linear systems are required prerequisites of the Photonics Theory/Lab senior electives. Theory courses in either Photonics, Optics, Optical Electronics, or Optical Systems Design can be followed with more advanced courses such as Physical or Fourier optics or others offered in the department of ECEE.

Representative Technical Applications
- Laser diodes, solid state lasers, tunable lasers, ultrafast lasers, and other novel light sources
- Holography for display and storage, interferometric metrology
- Fiber optic components, lasers, detectors, amplifiers, modulators
- Microscopes, Telescopes, Spectrometers, Polarimeters, Interferometers
- Quantum optics, quantum encryption, quantum information processing
- Nonlinear optics based information processing, frequency conversion

Representative Societal Applications
- Optical data storage (CDs, DVDs, holographic storage)
- Fiber optic communication (internet backbone, fiber to the home)
- Imaging (digital cameras for consumer, microscopy, medical, defense, astronomy applications)
- Displays (for computers, portable devices, video and art, including 3-D displays)
- Electronic-photonic circuits (next generation ICs and planar lightwave integrated circuits)
- Lasers sources (precision metrology, spectroscopy, time and frequency standards)
- Energy conversion (semiconductor and organic solar cells)

Alternate theory course:
ECEN 4645 Optical Electronics

Advanced follow on courses:
ECEN 5696 Fourier Optics and Imaging
ECEN 5156 Physical Optics
ECEN 5166 Guided Wave Optics
Power Electronics

Core prerequisite: Microelectronics, ECEN 3250
ECEN 4797 – Introduction to Power Electronics
ECEN 4517 – Power Electronics Laboratory

Faculty advisors: K. Afridi, R. Erickson, D. Maksimovic

Although vast majority of electronic signal processing and computing is now performed digitally, signal and power generation and delivery remain fundamentally analog. Interfaces between sensors such as microphones, temperature, motion or optical sensors and digital computers involve analog signal conditioning and analog-to-digital conversion. Similarly, digital computer outputs, such as audio or communication signals must be ultimately converted to real-world analog signals via digital-to-analog converters. All electronic systems require efficient, tightly regulated power supplies. Advances in power electronics have enabled improved operating life of battery powered electronics, significant energy savings and reductions in size and cost in all electronic systems, as well as more effective utilization of renewable energy sources such as wind or solar. Performance of systems ranging from cell phones to audio or video players, to medical instrumentation, measurement devices, or renewable energy systems is often determined by the noise, bandwidth or efficiency of analog and power microelectronics.

Basic understanding of transistors and other semiconductor devices, as well as circuit analysis techniques in time and frequency domains, are necessary to learn about circuit design techniques in microelectronics. ECEN 2250, ECEN 2260 and ECEN 3250 are therefore essential prerequisites for the senior power electronics and analog integrated circuit design courses. In the Introduction to Power Electronics and the Power Electronics Laboratory, we address analysis, modeling and design of switched-mode power conversion circuits capable of supplying arbitrary tightly regulated voltages and currents at very high efficiencies. The lab culminates with a project where students design, build and test power electronics for a complete solar power system. Analog Integrated Circuits Design addresses transistor-level circuit design of current and voltage references, amplifiers, comparators, analog-to-digital and digital-to-analog converters with numerous applications in audio, video, radio-frequency and sensor interfaces. Microelectronics is a good area for those who enjoy hands-on circuit design, experimentation, and applications.

Representative Technical Applications
- Efficient electrical power processing and power management
- Signal conditioning, analog-to-digital and digital-to-analog conversion
- Audio, video, radio-frequency and sensor interfaces

Representative Societal Applications
- Energy efficiency and energy savings
- Effective utilization of renewable energy sources
- Computing and communication infrastructure
- Sensors and instrumentation: environmental, medical, industrial
Renewable Energy

Core prerequisite: Circuits as Systems, ECEN 2260
ECEN 3170 – Electromagnetic Energy Conversion I (co-requisite Microelectronics, ECEN 3250)
ECEN 4167 – Electromagnetic Energy Conversion II
Faculty advisors: H. Hilgers (adjunct faculty)

Renewable energy was established as a new field about 20 years ago with the design of wind and photovoltaic power plants. Although in some areas great progress has been made, it is still insufficient to cover the electric energy needs of our nation which requires a total installed power capacity of about 800GW with a spinning reserve of about 80GW. The latter is required because the electricity consumed by residential, commercial and industrial loads must be generated at the very moment when consummation occurs. This requirement cannot be met by renewable energies alone because they are intermittent in their energy production and even meteorological forecasts cannot alleviate this problem. In addition, the change of the wind, for example, may result in the loss of 60MW per minute. This loss of generation capacity can only be covered either by conventional plants (e.g., natural gas or coal-fired plants) or by energy storage facilities, and to a lesser extent by nuclear plants which serve mostly as base load plants due to the long thermal time constants of the nuclear reactor.

Applications range from the development of new algorithms for the control of distributed systems (DG), load flow analyses for fundamental and harmonics as required by power system control centers, the development of emergency operational procedures in case of brown- or blackouts, the interaction of renewable plants with energy storage plants. From the Dutch experiences one can conclude that renewable energy of 30% of the entire required power, that is, in our nation’s case 240GW, poses tremendous control problems. Needless to say, the range of application is enormous.

To study renewable energy systems, it is necessary to have a good grounding in basic laws and theorems of electrical engineering. The prerequisite for the sophomore, senior, and cross-listed graduate courses is Circuits and Electronics 1 and 3. In addition, real-time applications require some experience in computer languages such as Quick Basic, C++, D/D, D/A and A/D converters, and other soft- and hardware. Off-line processing requires the use of high-level application languages like MATLAB, MATHEMATICA and SPICE. The renewable energy field is a good area for those who want to contribute to solving the problems of society and who enjoy the design and development of power system and power electronic components, applied mathematics, and applications.

Representative Technical Applications
- Renewable energy sources such as wind- photovoltaic and co-generation
- Large-scale energy storage to mitigate intermittent nature of renewable sources: design of pumped-storage hydro plants, compressed air storage plants, emergency and standby power supplies, and uninterruptible power supplies for data processing equipment
- Design of large-scale machines, rectifiers and inverters
- AC and DC transmission of electrical energy, voltage- and frequency control of systems with distributed generation
- Energy conservation
- Replacement of internal combustion engine (IC) by electric drives based on either fuel cells or batteries/supercapacitors

Representative Societal Applications
- Reduction of particulates, sulfur and carbon dioxide emissions
- Providing fuel (electricity from renewable sources) for public and individual transportation
Program Enrichment Options

Concurrent BS/MS Program
Certificate Programs
Biomedical Engineering Option (BIM)
Engineering Honors Program
Other International Opportunities
Student Societies for EE/ECE
**Concurrent BS/MS Program**

Students with strong academic records who plan to continue in the Graduate School for a Masters in the same discipline usually find it advantageous to apply for admission to the concurrent BS/MS degree program.

**Purpose of the Program**

The concurrent BS/MS program in Electrical, Computer, and Energy Engineering enables especially well-qualified students to be admitted to the MS program during the junior year of their BS program, and to work thereafter towards both the BS and MS degrees in Electrical and Computer Engineering. This program allows for early planning of the MS portion of the student’s education, taking graduate courses as part of the BS degree, more flexibility in the order in which courses are taken, and more efficient use of what would otherwise be a final semester with a light credit hour load. Due to the tighter coordination of courses within the ECEE Department than is possible for students who come to UCB from other institutions to pursue the MS degree, up to six (6) credit hours may be counted toward both the BS and MS degree programs.

**Admission to the Program**

Application for admission to the Concurrent BS/MS program in the ECEE Department may be made at any time during or after the student enters his or her junior year. Minimum requirements for admission to the concurrent program are: (i) completion of the eight core EE courses, (II) a minimum overall GPA of 3.25, (iii) a minimum GPA of 3.25 in ECEE Department courses, and (iv) at least three (3) letters of recommendation must be provided by the applicant (at least two (2) must be from ECEE faculty at UCB). Transfer students in place of requirement (i) above, must have taken at least two (2) of the core ECEE courses at the Boulder campus and have completed coursework at another institution (or other institutions) which is approved for the transfer credit equivalent to all ECEE core courses not taken on the Boulder campus, and must have completed at least 15 credit hours of total courses at UCB in order to qualify for admission.

**Staying in the Program**

The student must maintain a GPA of at least 3.0 over all undergraduate courses taken, and a GPA of at least 3.0 in all graduate courses taken in order to remain in good standing in the program.

**Regulations**

Until a student in this program reaches a total of 128 credit hours of courses applicable to the BS or MS degree in Electrical and Computer Engineering taken and passed (each with a grade of D or better), he/she will be governed by the rules and regulations applicable to any undergraduate student in the ECEE Department, unless specified otherwise in the regulations described herein. After a student has accumulated a total of 128 applicable credit hours, he/she will be governed by the rules and regulations applicable to any graduate student in the ECEE Department, unless specified otherwise in the regulations described herein. It is the intention of the department that, as far as possible, a student in this program is treated on the same basis as any other student in the department at a comparable stage of their academic career.

**Overlapping Credit**

With the recommendation of the student’s academic advisor and the approval of the ECEE Graduate Coordinator, as many as six (6) credit hours of ECEE Department courses at the 5000 level or above may be counted both toward the undergraduate degree requirements and the requirements for the MS degree. Therefore, the minimum number of credits for the Concurrent BS/MS degree is 152. Courses used in the BS/MS may not be used towards a PhD.

**Advising**

Students in the Concurrent BS/MS program must have a faculty advisor with whom they must consult to compose a degree plan, including a list of courses to be taken from the senior year through the end of the program. This plan must be filed with the ECEE Department Coordinator for Undergraduate Studies by the end of the third week of the first semester in which the student has been admitted into the program.
Certificate Programs

Certificate programs are similar to minor programs, and upon completion will be identified on the student’s transcript immediately following the semester in which the certificate was completed. It is possible that course work used to satisfy a certificate can also be used for free electives, technical electives, or humanities/social sciences electives. Check with the Undergraduate Advisor to determine how a certificate program fits in with your degree plans.

Embedded System Design

Commercially available digital systems (microprocessors, microcontrollers, memory chips, interface systems, and systems that handle image, voice, music, and other types of signals) have experienced explosive growth in the electronics industry. These devices are increasingly powerful, cheap, and flexible as design components. The certificate in embedded system design offers students the hardware and software knowledge, and the skills needed to design and implement these systems. The curriculum consists of two core courses and one elective course from an approved list. The two core courses are:

- ECEN 4613 Embedded System Design
- ECEN 4623 Real-Time Embedded Systems or
- ECEN 4653 Real-Time Media Design

The list of approved electives is periodically updated and currently includes:

- ECEN 4610/20 Capstone Laboratory


Information on these certificate programs may be found at [http://engineering.colorado.edu/academics](http://engineering.colorado.edu/academics).

ATLAS

The Alliance for Technology, Learning, and Society (ATLAS) offers two certificates: Technology, Arts, and Media (TAM) and Multidisciplinary Applied Technologies (MAT). Both require 18 credit hours. For additional information, call 303-735-6588 or visit the website: [http://www.colorado.edu/ATLAS](http://www.colorado.edu/ATLAS).

College of Arts and Sciences

Arts and Sciences offers certificate programs in the following areas: Actuarial Studies, British Studies, Central and Eastern European Studies, Cognitive Sciences, Lesbian, Gay, Bisexual, and Transgender Studies, Medieval and Early Modern Studies, Neurosciences and Behavior, Peace and Conflict Studies, and Western American Studies. Completion of specified course work in these programs entitles students to a certificate issued by the Dean of Arts & Sciences. Students interested in these programs should contact the appropriate program.
Biomedical Engineering Option (BIM)

The Biomedical Engineering (BIM) option, available to both electrical and computer engineering majors, focuses on the application of biophysical and engineering concepts to the improvement and protection of human health. Successful completion of this option is noted on a student’s transcript and meets most medical school admission requirements.

Coursework in the Electrical and Computer Engineering curriculum is coupled with specialized courses linking electrical engineering to biomedical applications such as neural signals and systems, bioeffects of electromagnetic fields, therapeutic and diagnostic uses of bioelectric phenomena and medical image processing. Undergraduates may also elect independent study courses in these areas.

Students interested in the option may receive elective credit for two semesters of biology if they also complete two bioengineering courses from the ECEE offerings. One of these ECEE courses also may be used to satisfy distribution requirements. The basic BIM option includes two semesters of biology and two junior or senior bioengineering courses in the ECEE Department taken in lieu of other electives. Several of these electives are also applicable to the Boulder campus Neurosciences Program. ECEE Biomedical Engineering courses regularly offered include:

ECEN 40x1 Special Topics in Biomedical Engineering

For more information on pre-medical studies in ECEE contact the Pre-Professional Advisors in the Academic Advising Center for the College of Arts & Sciences. For specific advice on fitting the BIM Option into an existing EE/ECE program contact the Undergraduate Staff Advisor.

Engineering Honors Program

The Engineering Honors Program was created as an educational experience for our very best students that not only included the classroom, but significantly transcended the classroom. To do this, we are building an educational culture whose core values are excellence, community and opportunity.

Excellence: excellence is not an abstract value or virtue, but something very concrete. It is what happens when talented individuals choose to do excellent things. It requires both expecting the best from yourself and others, and being ambitious without being competitive

Community: belonging to a group that comes together to encourage, support, inspire and enjoy one another in the pursuit of excellence. On a very practical level, it means entering a group of advanced peers already succeeding and expanding the possibilities for you

Opportunity: creating an overall educational experience (special classes, research positions, internships, study abroad, service projects, mentors, leadership training) that matches your individual abilities and ambitions.

There will be a combination of college-wide and department-specific Honors experiences beginning your very first semester. Learn more about EHP at http://www.cuhonorsengineering.com/
Other International Opportunities

Study Abroad
The Study Abroad Program housed within the Office of International Education in the Environmental Design building and has over 200 CU approved Study Abroad programs all over the world. Programs may vary in length, with summer, semester and year-long offerings. If you register for a CU program, you earn in-residence credit and are eligible for financial aid. For more information call 303-492-7741 or visit [http://studyabroad.Colorado.edu/](http://studyabroad.Colorado.edu/).

CU Engineering Global E 3
Beginning in the fall of 2009, CU will now be participating in the Global Engineering Education Exchange (Global E 3). CU Engineering students will be able to participate in Study Abroad and take engineering courses at over 40 universities all over the world. For more information, please contact Assistant Dean Mary Steiner, 303-492-7696, MSteiner@colorado.edu.

Engineers Without Borders
The student organization Engineers Without Borders is committed to researching sustainable development by practicing in developing countries around the world. CU Engineering students have traveled to Rwanda, Peru, Tibet and other countries to set up sustainable systems. For more information regarding this and other programs for developing communities, please contact Robyn Sandekian, 303-735-6708, sandekian@colorado.edu.
Student Societies for EE/ECE

Eta Kappa Nu (HKN) - Rho Chapter

About HKN

Eta Kappa Nu is a nation-wide organization that is dedicated to encouraging and recognizing excellence in the electrical and computer engineering field. It was founded in 1904 at the University of Illinois by ten students as the vision of an organization recognizing academic excellence in electrical engineering.

The local Rho Chapter at the University of Colorado dates back to March 4, 1922 and consists of electrical engineering students who are excited about the possibilities of our major and are willing to share this with anyone who might ask. The chapter hosts several service and social events throughout the year, including a series of seminars that focus on teaching technical skills that are not typically taught, but yet are very useful for the engineering student or practicing engineer. The chapter also hosts small social events where students can wind down from a tough day in the books.

The Rho Chapter is one of a select few which has won the HKN Outstanding Chapter Award two years in a row. For more information, look online at http://hkn.colorado.edu or contact the current president, Kelly Shuster at hkn@colorado.edu

IEEE Student Group

About IEEE

A non-profit organization, IEEE is the world’s leading professional association for the advancement of technology. The IEEE name was originally an acronym for the Institute of Electrical and Electronics Engineers, Inc. Today, the organization’s scope of interest has expanded into so many related fields, that it is simply referred to by the letters I-E-E-E (pronounced Eye-triple-E).

Benefits

• Monthly events on campus ranging from social gatherings to technical talks with industry
• Technical workshops and events throughout the year
• IEEE Potentials and Spectrum Magazines
• The IEEE, in conjunction with Microsoft, is pleased to offer a wide selection of development software to IEEE Student members.
• All benefits can be found at http://www.ieee.org/benefits

Quick Facts

• More than 375,000 members including nearly 80,000 student members in more than 160 countries
• 324 sections in ten geographic regions worldwide
• 1,784 chapters that unite local members with similar technical interests
• 1,616 student branches and 452 student branch chapters at colleges and universities in 80 countries
• 38 societies and 7 technical councils representing the wide range of technical interests

To Join

Go to http://www.ieee.org/join

For details, events, and forum please visit our web site at http://ieee.colorado.edu
Other Information

Department Regulations and Other Useful Information
Minimum Academic Preparation Standards (MAPS)
Advising Resources
ECEE Teaching Faculty
Engineering Center Map
Department Regulations and Other Useful Information

Students with questions concerning Departmental regulations and requirements should check with the Undergraduate Staff Advisor first. In some cases, Department regulations differ from those of the College of Engineering. Students should make themselves aware of the following regulations, as well as the those in the College Advising Guides.

Advanced Placement, International Baccalaureate, College-Level Examination Program
AP, IB, and CLEP credit is handled as transfer credit. For students who have taken an advanced placement course in high school and who have attained the required score in the College Entrance Examination Board’s Advanced Placement examination, advanced placement and college credit may be granted if the subject would normally be part of the student’s curriculum. If the student elects to take the equivalent college course, the credit for that course will replace the advanced placement credit. For a listing of AP examinations, score required for credit, and equivalent courses at CU-Boulder, please refer to the current University of Colorado at Boulder Catalog. You may also find this information at: http://www.colorado.edu/prospective/freshman/admission/criteria.html

Colorado Space Grant Consortium (COSGC)
The COSGC is funded by NASA and is a state-wide organization involving 13 colleges, universities and institutions around Colorado. This group provides Colorado students access to space through innovative courses, real-world hands-on telescope and satellite programs. Students interact with engineers and scientists from NASA and aerospace companies to develop, test, and fly new space technologies. Many EE and ECE majors find working for Space Grant a way to practice and develop their engineering skills. Find more information at http://spacegrant.colorado.edu.

Degree Audit System (DARS)
The advising system used by the University of Colorado to track student progress is known as DARS. You are able to access the system through mycuinfo. This system provides a degree audit which will aid you in schedule planning and tracking your degree progress.

Discovery Learning Apprenticeships
Undergraduate students are encouraged to apply for the opportunity to conduct research via a Discovery learning apprenticeship. Students can earn an hourly wage while engaging in research with college faculty and graduate students. Positions are announced in April for the following fall term and spring term. Students must apply and selection for positions is competitive. For more information, an application and a list of current discovery learning projects visit http://engineering.colorado.edu/activelearning/discovery.htm.

Double Degrees
It is possible to obtain bachelor’s degrees in two engineering disciplines. Students must satisfy curricula for both programs and complete a minimum of 30 additional hours beyond the largest minimum required by either program. Of the 30 additional semester credit hours, double degree students must complete 24 semester credit hours in courses offered by the secondary academic department or in courses approved in advance by the department as substitutes. Transfer students pursuing double degrees must complete a minimum of 75 semester credit hours as a degree student in the College of Engineering and Applied Science and must satisfy all other stipulations regarding total hours required and approval of all coursework by both departments concerned.

E-Mail Communication
E-mail is an official means of communication within the CU-Boulder community. Therefore, the University has the right to send communication to students via e-mail and expect that those communications will be received and read in a timely fashion. The campus recommends checking e-mail once per week, at minimum, because some communications may be time critical. Additionally, the department maintains e-mail lists for communication with its students. You will be automatically placed on this list when you are accepted into the department. If you wish to be removed from this list, contact the Undergraduate Staff Advisor.
**Engineering Management/Business/Economics Courses**

Engineering Management courses equip students with technical management expertise. Areas of technical management emphasis are in quality and process, research and development, operations, and project management. Business and Economics courses help prepare students for positions in management and with a better understanding of how industry works. Engineering Management, Business or Economics courses at the 3000 or higher level may be used to satisfy technical elective requirements for a B.S. degree up to a maximum of 6 credit hours.

**Free Electives**

The curriculum includes a maximum of 6 credit hours of free electives which are optional but do counts towards the total credits hours for the degree. Free electives may be any course that covers different material than other courses the student has taken. For example, a student may not take APPM 1350 Calculus 1 for Engineers and MATH 1300 Analytic Geometry/Calculus 1 and receive credit for both.

**GPA**

In addition to other University requirements, each student must satisfy the following at the time of graduation: a cumulative grade point average of 2.25 in all courses taken on any campus at the University of Colorado; a cumulative grade point average of 2.25 in all departmental courses (labeled ECEN xxxx or cross-listed with ECEN) taken on any campus at the University of Colorado. “Courses taken” means all courses for which a letter grade has been received, including all grades for repeated courses.

**Grades**

Faculty within this College have the option of awarding grades with a plus (+) or minus (-) designation, except for A+. Faculty who teach courses have complete authority for calculating and assigning final grades in courses they teach. A final grade of “D-” or better in a course is sufficient to satisfy degree requirements unless the course is a prerequisite for another course in the student’s program (see Prerequisite Requirements).

**Graduate-Level Courses**

Courses in ECEN at the 5000-level are closed to undergraduates with a GPA of less than 2.85 except by petition. Other campus departments may have different restrictions. Courses at the 6000-and 7000-level are closed to all undergraduate students. Graduate level courses applied towards the graduation requirement for the B.S. degree cannot be used again toward a graduate degree, either here or at another school. The only exception to this rule is students who are enrolled in the Concurrent BS/MS program. See the section about the Concurrent BS/MS program for further details.

**Graduation Check**

Each student should make an appointment with the Undergraduate Staff Advisor one semester prior to the semester in which he or she plans to graduate to review credits toward graduation. Even though all students are invited to review credits several times throughout their studies, this final graduation check is mandatory. If a student has not been through the graduation check and problems are found at graduation, an extra semester may be necessary. Also see the “Graduation Checklist” on page 21.

**Honors**

Students graduating with a cumulative GPA between 3.70 and 3.79 will be awarded the designation “Cum Laude” on their diploma and in the commencement program. A GPA of 3.80 to 3.89 earns the citation “Magna Cum Laude.” and a GPA of 3.90 to 4.00 earns the citation “Summa Cum Laude.” Grades earned during the semester of graduation will be considered and awards adjusted if necessary.

Eligible students are also encouraged to participate in the College of Engineering Honors Program. This is a separate program. Interested students should consult with the Director of the Engineering Honors Program for detailed information.
Independent Study

A maximum of 6 credit hours of upper division independent study (ECEN 3840/4840) may be used as a technical electives to fulfill Technical Electives requirements. If it is used to fulfill any other requirement, it must be approved ahead of time by petition. Any Independent Study course sponsored by a faculty member in another department must be approved by petition and may not be used to fulfill the senior theory or lab requirements. If interested, an Independent Study Agreement form must be completed and signed by both the student and the sponsor of the Independent Study or Undergraduate Research. These forms are available from the Undergraduate Staff Advisor and also on the ECEE website. Students should use the faculty list section on page 48 of this HELP! Guide to determine the appropriate faculty member to contact.

No Credit and Pass/Fail

A course taken for no credit or pass/fail cannot be used for fulfilling graduation requirements except by petitioning a pass/fail course as a Free Elective. Once a course has been taken for no credit it cannot be repeated for a grade. Students are still subject to course tuition and fee expenses when registering for a course with the NC option.

Non-Track Technical Electives/Technical Electives

All courses used for technical electives must be at the 3000 level or above. Courses of a technical nature offered by ECEN, other departments in the College of Engineering, APPM, MATH, and PHYS may be used. Six hours of 3000 or above business, engineering management or economics courses may also be used by petition.

Petitions

Any exceptions to department or college rules must have prior approval by petition. All petitions must be submitted to the Undergraduate Staff Advisor for departmental approval. Petitions involving exceptions to College rules will then be submitted to the Dean’s Office for approval. It is the student’s responsibility to find out if a petition has or has not been approved. Blank petition forms are available from the Undergraduate Staff Advisor, online on the ECEE website, and the Dean’s Office (ECAD 100).

Prerequisite Requirements

The minimum passing grade for a course that is considered a prerequisite for another course is C-. If a grade of D+ or lower is received in a course which is prerequisite to another, the student is required to repeat the course until the minimum acceptable course grade has been earned. However, no course may be repeated more than three times. If a student takes the advanced course, it does not remove the obligation to repeat the prerequisite course, even if the grade earned in the advanced course is a C- or above. The minimum passing grade for a course that is not specifically a prerequisite for another course taken is D-. All EE core and Advanced Analog core courses are considered prerequisites for the Capstone Senior Lab, semester 2. Capstone Lab parts 1 & 2 require a minimum grade of C-. See the list and chart for prerequisite courses.

Repeating Courses

All instances of all courses will be included in the cumulative GPA. A required course in which a successful grade has not been received must be repeated until the appropriate grade is attained. However, no course which is required for the degree may be taken more than 3 times. If a course is taken 3 times and still has not been successfully completed, the student will be dropped from the department and must apply to another major.

ROTC

Students participating in the ROTC program may use approved ROTC coursework as credit toward fulfilling ECEN BS degree requirements. Normally, 6 hours are used as Free Electives and 6 hours are used as Humanities/Social Science Electives. Some ROTC courses with technical content may occasionally be used as a technical elective, but this is only done by petition.
Technical Electives (non-track)
Students must fulfill all requirements listed for either the EE or ECE degree. However, once these requirements are fulfilled students may not have the required 128 credit hours for the degree. To complete these hours students will take general technical electives which may consist of the following:
- ECEN 3000/4000 level courses
- 3000/4000 level technical courses in other Engineering departments
- 3000/4000 level APPM, MATH, PHYS, CHEM courses
- 3000/4000 level business, EMEN, TLEN, ECON courses for a maximum of 6 hours (see details on page 42)

Telecommunications Courses
The graduate Telecommunications Program offers special courses, most of which are usually not suitable as technical electives in the departmental programs. Therefore, a student may use only that Telecommunications course for which he or she has received prior approval, by petition, in his or her degree program. Only one approved Telecommunications course may be applied to the B.S. program. A brochure listing courses offered in the Telecommunications Program may be obtained in the Telecommunications Office (OT 313).

Transfer Credits
The initial transfer credit evaluation is performed by the Office of Admissions upon receiving an official transcript mailed directly from the institution where the credit was earned. Once the Office of Admissions has completed their evaluation, the ECEN Transfer Credit Evaluator or Undergraduate Advisor can verify which courses can be applied to the Department’s curriculum. The Office of Admissions will not accept course work in which the student received a grade lower than a C-. Nor will Pass/Fail credit be accepted. Credits from an Engineering Technology program normally will not transfer, and no academic credit is given for work or co-op experience. Credit received more than 10 years prior to admission will not be accepted except by petition of exam.
All transfer students should see the Department’s Transfer Credit Evaluator about acceptance of transfer credits before classes begin or prior to taking classes at another institution while a student at CU Boulder. (Those transferring here from UCD or UCCS are not considered transfer students, but they should review their credits with the Undergraduate Staff Advisor in order to determine how credits received at another campus will fit into this program. A chart of course equivalencies may be found at http://www.colorado.edu/catalog/2012-13/content/cu-system-course-equivalencies-table. Once the Transfer Credit Evaluator has approved transfer hours, the student should deliver a copy of the signed sheet to the Undergraduate Staff Advisor in the Undergraduate Office to be made a part of his or her departmental file.

45-Hour Rule
Students admitted to the CU-Boulder College of Engineering must complete their last 45 hours on the Boulder campus or through CAETE (Center for Advanced Engineering & Technology Education). Any exceptions to the 45-hour rule must be approved by petition in advance of registering for those courses. Courses taken without prior approval will not be counted toward the degree.
**Minimum Academic Preparation Standards (MAPS)**

All students entering the University of Colorado who finished high school in the spring of 1988 or thereafter must meet Minimum Academic Preparation Standards specified by each school or college. The College of Engineering and Applied Sciences has adopted the following standards for admission. These standards are defined in high school units. A unit is one academic year of course work.

1. English 4 units
2. Mathematics 4 units (including 2 algebra, 1 geometry, and 1 college prep, eg. trigonometry)
3. Natural Science 3 units (including 1 unit in chemistry and 1 unit in physics)
4. Social Science 3 units
5. Foreign Language 3 units of the same language, or 2 units each in 2 different languages

**Policies Concerning MAPS Deficiencies**

Students who are admitted to the College of Engineering with a deficiency in one or more of the above categories are required to complete the appropriate courses through courses taken at CU-Boulder or other institutions of higher education or approved credit-by-examination programs prior to their graduation from college.

The policies of the Boulder campus with respect to completing MAPS coursework after enrollment are as follows:

1. Appropriate missing MAPS course work may be included in the hours for graduation.
2. All coursework taken to fulfill MAPS deficiencies must be taken for a letter grade.
3. Students are required to enroll in and complete at least one MAPS course each term, beginning in the first term of enrollment, until all MAPS units are completed. This policy applies to new freshmen, to transfer students, and to students transferring from other academic units on the Boulder campus and from other campuses of the University. Failure to comply with this requirement may result in suspension at the end of the term in which the student ceases taking courses to complete missing MAPS units.
4. All students who first enroll in one academic college or school at CU-Boulder and who subsequently transfer to another college or school are required to meet the MAPS specified for the new unit, irrespective of their completion of MAPS units in their previous college or school.
5. Students in double-degree programs must meet MAPS requirements of both degree-granting programs.
6. Students must consult with a CU-Boulder academic advisor (or read the University’s Course Catalog for course descriptions) to determine which specific courses may be used to meet a MAPS requirement.
7. Students who graduate from a foreign high school are exempt from MAPS requirements.
Advising Resources

There are many advising resources available to students at CU-Boulder, but students frequently do not know about them. Please do not hesitate to contact any of these offices for assistance or use their on-line tools.

BOLD Center

The Broadening Opportunity through Leadership and Diversity (BOLD) Center is an academic excellence community committed to serving students from a wide range of backgrounds and to preparing engineers with diverse perspectives to be innovative leaders in a global society. BOLD offers a dynamic “collaborative learning” curriculum that supports CU students in successfully achieving their educational and career goals. Take advantage of great academic services such as free tutoring and programs proven to help you boost your grades. The BOLD Center is located in ECCE 110 and their website is at [http://engineering.colorado.edu/bold/index_old.html](http://engineering.colorado.edu/bold/index_old.html).

Career Counseling in Career Services

The professional career counselors can help students and alumni clarify career interests, values and work-related skills; explore potential careers and employers; and refine job seeking, interviewing, and resume preparation skills. They host Career Fairs and Internship Fairs, sponsor resume writing workshops, and hold mock interview sessions. Career Services is located in C4C, room N352 (303-492-6541), or you may visit their website at [http://careerservices.colorado.edu/public/](http://careerservices.colorado.edu/public/).

Career Services Online (CSO)

Search jobs and internship listings, apply for on-campus interviews, and get weekly e-mail updates about career events. Sign up at [http://careerservices.colorado.edu/public/](http://careerservices.colorado.edu/public/).

Counseling and Psychological Services: A Multicultural Center

This center provides a variety of programs and assistance to address general academic or personal issues. They are located in C4C, room S440, or call 303-492-6766.

Degree Audit System (DARS)

The advising system used by the University of Colorado to track student progress is known as DARS. You are able to access the system through mycuinfo. This system provides a degree audit which will aid you in schedule planning and tracking your degree progress.

Engineering Peer Advocates Office

This office provides services which include academic advising, assistance with major selection, tutoring, and test files as well as providing general information about study skills, test anxiety, resume writing, study abroad opportunities and much more. The office is staffed by sophomores, juniors, and seniors who have been trained to answer questions about anything that may affect you as an engineering student. It is located in ECCR 263 (303-492-0828), and is open and free to all current and prospective engineering students.

Pre-Professional Advising Center

Located in Old Main, room 1B90 (303-735-3000), the advisors provide support services to all CU-Boulder students preparing for careers in the medical sciences, health professions, and law.

Student Academic Success Center

SASC is a multi-cultural academic learning community, serving students, especially low income and first generation college students, with academic skills development, math and writing courses, supplementary instruction in gateway courses, tutoring, pre-collegiate opportunities and graduate research opportunities. Weekly Academic Skills Development workshops are offered throughout the year which are open to all students. They are located in the Fleming Building, Room 141.

(C4C is the Center for Community)
## ECEE Teaching Faculty

*(Area code 303)*

<table>
<thead>
<tr>
<th>Professor</th>
<th>Office</th>
<th>Telephone</th>
<th>E-mail</th>
<th>Area of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khurram Afridi</td>
<td>OT 342</td>
<td>492-8905</td>
<td><a href="mailto:kthurram.afridi@colorado.edu">kthurram.afridi@colorado.edu</a></td>
<td>Power Electronics</td>
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Engineering Center Map

Engineering Center