DEPARTMENT OF
Electrical, Computer, & Energy
ENGINEERING

Help! Guide

Fall 2011-Spring 2012

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/

Colorado
University of Colorado at Boulder

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Welcome to Electrical, Computer, and Energy 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.

Electrical, Computer, & Energy Engineering Advisors

Associate Chair and Head of the Undergraduate Program:

Prof. Peter Mathys	ECEE 1B67	303-492-7733

Undergraduate Staff Curriculum Advisor:

Ms. Valerie Matthews	ECEE 1B20	303-492-7671

Freshman Advisors:

Prof. Andrew Pleszkun	ECOT 334	303-735-6319
Prof. Juliet Gopinath	ECEE 1B43	303-492-5568

Transfer Credit Evaluator:

Prof. Ed Kuester	ECOT 248	303-492-5173

Academic and Career Advisors:

Your assigned faculty advisor or any ECEE faculty member

Career Advising outside the department:

Career Services Office Willard Hall
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 Mircosystems, National Instruments, 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.

Electrical, Computer, and Energy Engineering Disciplines

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)

Math (16 hours)

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	

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	
	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	
MCDB 1150	Intro to Molecular Biology	3	
IPHY 3410	Intro to Human Anatomy	3	

Computer Programming (4 hours)

ECEN 1030	C Programming for EE/ECE*	4	

*(May substitute CSCI 1300 for transfers only)

Sophomore Electives (6 hours) choose two:

ECEN 2410	Renewable Energy	3	*F*
ECEN 2420	Wireless Electronics	3	*S*
ECEN 2430	Robotics & Controls	3	*S*
ECEN 2440	Application of Embedded Systems	3	*F*

Electrical Engineering Core (21 hours)

ECEN 2250	Intro to Circuits & Electronics	3	
ECEN 2260	Circuits as Systems	3	
ECEN 2270	Electronics Design Lab	3	
ECEN 2350	Digtal Logic	3	
ECEN 3350	Programming of Digital Systems	3	
ECEN 3360	Digital Design Lab	3	
ECEN 3810	Probability**	3	*F*

**(May substitute APPM 3570 or MATH 4510)

Advanced Analog Core (9 hours)

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

Technical Electives (22-24 hours)

Must fulfill requirements for two "tracks" (see page 24)

ECEN 4242	Communication Theory	3	*F*
ECEN 4652	Communication Lab	2	*F/D*
ECEN 4532	Digital Signal Processing Lab	3	*S/D*
ECEN 4632	Intro to Digital Filtering	3	*S*
ECEN 4138	Control Systems Analysis	3	*F/D*
ECEN 4638	Controls Lab	2	*F/D*
ECEN 3410	EM Waves & Transmissions	3	*S*
ECEN 4634	Microwave/RF Lab	3	*F/D*
ECEN 4827	Analog IC Design	3	*F/D*
ECEN 4837	Mixed Signal IC Design Lab	3	S/D
ECEN 3320	Semiconductor Devices	3	*F*
ECEN 4555	Prin of Energy Systems/Devices	3	*F/D*
ECEN 4375	Microstructures Lab	3	*S****
ECEN 4831	Brains, Minds, & Computers	3	*F/D*
ECEN 4811	Neural Signals/Functnl Brain Imag	3	*S/D*
ECEN 4821	Neural Systems/Physiol. Control	3	*S/D*
ECEN 4606	Undergrad Optics Lab	3	*varies*
ECEN 4616	Optoelectronic System Design	3	*F*
ECEN 4106	Photonics	3	*F*
ECEN 4116	Intro to Optical Communication	3	*F/D*
ECEN 4645	Intro to Optical Electronics	3	*S/D*
ECEN 4797	Intro to Power Electronics	3	*F/D*
ECEN 4517	Renewable Power Electronics Lab	3	*S/D*
ECEN 3170	Energy Conversion	3	*F*
ECEN 4167	Energy Conversion 2	3	*S*

Non-track Technical Electives

ECEN 4224	High-Speed Digital Design	3	*S/D*
ECEN 4324	Fund of Microsystem Packaging	3	*F/D*
ECEN 4345	Intro to Solid State	3	*F/D*
ECEN 4553	Compiler Construction	3	*F/D*
ECEN 4583	Software Systems Development	3	*S*
ECEN 4593	Computer Organization	3	
ECEN 4613	Embedded System Design	3	
ECEN 4623	Real-Time Digital Embedded Systems	3	*F*
ECEN 4633	Hybrid Embedded Systems	3	
ECEN 4643	Real-Time Digital Media Systems	3	*S*
ECEN 4---	Selected Special Topics	3	

Other <u>technical</u> courses to complete 128 hour requirement. May use 6 hrs EMEN/Business/ECON or 3 hrs UD Free Elective. Check with Advisor for applicability.

Capstone Design Lab (5 hours)

ECEN 4600	Capstone Laboratory, Part 1	2	*F*
ECEN 4620	Capstone Laboratory, Part 2	3	*S*

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
****offered only in even years*

Sample Schedule for *Electrical Engineering* Program

Freshman Year

Fall

Course	Title		Hrs
APPM 1350	Calculus 1		4
PHYS 1110	Physics 1		4
ECEN 1100	Freshman Seminar	*F*	1
ECEN 1400	Freshman Elective*		3
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		15

Spring

Course	Title		Hrs
APPM 1360	Calculus 2		4
PHYS 1120	Physics 2		4
PHYS 1140	Experimental Physics		1
ECEN 1030	C Programming for EE/ECE*		4
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		16

Sophomore Year

Fall

Course	Title		Hrs
APPM 2360	Diff. Eq. with Linear Algebra		4
ECEN 24--	Sophomore Elective 1		3
ECEN 2250	Intro to Circuits & Electronics		3
ECEN 2350	Digital Logic		3
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		16

Spring

Course	Title		Hrs
APPM 2350	Calculus 3		4
ECEN 24--	Sophomore Elective 2		3
ECEN 2260	Circuits as Systems		3
ECEN 2270	Electronics Design Lab		3
	General Science Elective**		3
	TOTAL CREDIT HOURS		16

Junior Year

Fall

Course	Title		Hrs
ECEN 3350	Programming of Digital Systems		3
ECEN 3810	Probability*	*F*	3
ECEN 3---	Advanced Analog Core		3
ECEN 3---	Advanced Analog Core		3
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		15

Spring

Course	Title		Hrs
ECEN 3360	Digital Design Lab		3
ECEN 3---	Advanced Analog Core		3
	Technical Electives**		6
	Approved upper-division writing		3
	Free Elective		3
	TOTAL CREDIT HOURS		18

Senior Year

Fall

Course	Title		Hrs
ECEN 4600	Capstone Lab: Part 1	*F*	2
	Technical Electives**		9
	Humanities & Social Sciences		3
	Free Elective		3
	TOTAL CREDIT HOURS		17

Spring

Course	Title		Hrs
ECEN 4620	Capstone Lab: Part 2	*S*	3
	Technical Electives**		9
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		15

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 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 (16 hours)

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	

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	
	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	
MCDB 1150	Intro to Molecular Biology	3	

Computer Programming (4 hours)

ECEN 1030	C Programming for EE/ECE*	4	

*(May substitute CSCI 1300 only for transfers)

Sophomore Electives (3 hours) choose one:

ECEN 2410	Renewable Energy	3	*F*
ECEN 2420	Wireless Systems	3	*S*
ECEN 2430	Robotics & Controls	3	*S*
ECEN 2440	Application of Embedded Systems	3	*F*

Electrical Engineering Core (21 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	
ECEN 3810	Probability**	3	*F*

**(May substitute APPM 3570 or MATH 4510)

Computer Engineering Core (10 hours)

ECEN 2703	Discrete Math for Computer Engineers	3	*F*
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)

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)

Technical Electives (15-18 hours)

Must fulfill requirements for one "track" (see page 24)

ECEN 4242	Communication Theory	3	*F*
ECEN 4652	Communication Lab	2	*F/D*
ECEN 4532	Digital Signal Processing Lab	3	*S/D*
ECEN 4632	Intro to Digital Filtering	3	*S*
ECEN 4138	Control Systems Analysis	3	*F/D*
ECEN 4638	Controls Lab	2	*F/D*
ECEN 3410	EM Waves & Transmissions	3	*S*
ECEN 4634	Microwave/RF Lab	3	*F/D*
ECEN 4827	Analog IC Design	3	*F/D*
ECEN 4837	Mixed Signal IC Design Lab	3	S/D
ECEN 3320	Semiconductor Devices	3	*F*
ECEN 4555	Prin of Energy Systems/Devices	3	*F/D*
ECEN 4375	Microstructures Lab	3	*S****
ECEN 4831	Brains, Minds, & Computers	3	*F/D*
ECEN 4811	Neural Signals/Functnl Brain Imag	3	*S/D*
ECEN 4821	Neural Systems/Physiol. Control	3	*S/D*
ECEN 4606	Undergrad Optics Lab	3	*varies*
ECEN 4616	Optoelectronic System Design	3	*F*
ECEN 4106	Photonics	3	*F*
ECEN 4116	Intro to Optical Communication	3	*F/D*
ECEN 4645	Intro to Optical Electronics	3	*S/D*
ECEN 4797	Intro to Power Electronics	3	*F/D*
ECEN 4517	Renewable Power Electronics Lab	3	*S/D*
ECEN 3170	Energy Conversion	3	*F*
ECEN 4167	Energy Conversion 2	3	*S*

Non-track Technical Electives

ECEN 4224	High-Speed Digital Design	3	*S/D*
ECEN 4324	Fund of Microsystem Packaging	3	*F/D*
ECEN 4345	Intro to Solid State	3	*F/D*
ECEN 4613	Embedded System Design	3	
ECEN 4623	Real-Time Digital Embedded Systems	3	*F*
ECEN 4633	Hybrid Embedded Systems	3	
ECEN 4643	Real-Time Digital Media Systems	3	*S*
ECEN 4---	Selected Special Topics	3	

Other technical courses to complete 128 hour requirement. May use 6 hrs EMEN/Business/ECON or 3 hrs UD Free Elective. Check with Advisor for applicability.

Software Electives (3-4 hours) choose one:

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

Capstone Design Lab (5 hours)

ECEN 4600	Capstone Laboratory, Part 1	2	*F*
ECEN 4620	Capstone Laboratory, Part 2	3	*S*

Free Electives (6 hours maximum)

Student choice of courses

F = fall only
S = spring only
D=undergrad & grad
****offered only in even years*

Sample Schedule for *Electrical & Computer Engineering* Program

Freshman Year

Fall

Course	Title		Hrs
APPM 1350	Calculus 1		4
PHYS 1110	Physics 1		4
ECEN 1100	Freshman Seminar	*F*	1
ECEN 1400	Freshman Elective		3
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		15

Spring

Course	Title		Hrs
APPM 1360	Calculus 2		4
PHYS 1120	Physics 2		4
PHYS 1140	Experimental Physics		1
ECEN 1030	C Programming for EE/ECE*		4
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		16

Sophomore Year

Fall

Course	Title		Hrs
APPM 2360	Diff. Eq. with Linear Algebra		4
ECEN 24--	Sophomore Elective		3
ECEN 2250	Intro to Circuits & Electronics		3
ECEN 2703	Discrete Mathematics	*F*	3
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		16

Spring

Course	Title		Hrs
APPM 2350	Calculus 3		4
ECEN 2350	Digital Logic		3
ECEN 2260	Circuits as Systems		3
ECEN 2270	Electronics Design Lab		3
	General Science Elective**		3
	TOTAL CREDIT HOURS		16

Junior Year

Fall

Course	Title		Hrs
ECEN 3350	Programming of Digital Systems		3
ECEN 3810	Probability*	*F*	3
ECEN 3---	Advanced Analog Core		3
CSCI 2270	Data Structures		4
	Humanities & Social Sciences		3
	TOTAL CREDIT HOURS		16

Spring

Course	Title		Hrs
ECEN 3360	Digital Design Lab		3
ECEN 4593	Computer Organization		3
ECEN 3---	Advanced Analog Core		3
	Technical Electives**		6
	Approved upper-division writing		3
	TOTAL CREDIT HOURS		18

Senior Year

Fall

Course	Title		Hrs
ECEN 4600	Capstone Lab: Part 1	*F*	2
	Technical Electives**		8
	Humanities & Social Sciences		3
	Free Elective		3
	TOTAL CREDIT HOURS		16

Spring

Course	Title		Hrs
ECEN 4620	Capstone Lab: Part 2	*S*	3
	Software Elective		3
	Technical Electives**		3
	Humanities & Social Sciences		3
	Free Elective		3
	TOTAL CREDIT HOURS		15

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 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

Course	*Title*	*Prerequisites and Co-requisites*	*Term offered*
General Courses		***Only final prerequisites are listed.***	
1030	C Programming for ECE	none	
1400	Intro to Digital & Analog Electronics	APPM 1350 (co-req)	
2250	Intro to Circuits & Electronics	APPM 1360, APPM 2360 (co-req)	
2260	Circuits as Systems	ECEN 2250	
2270	Electronics Design Lab (2830)	ECEN 2260 (co-req)	
2350	Digital Logic	ECEN 1030 or CSCI 1300	
2703	Discrete Mathematics	ECEN 1030 (CSCI 1300), APPM 1360	Fall
3250	Microelectronics	ECEN 2260	
3300	Linear Systems	ECEN 2260	
3350	Programming Digital Systems	ECEN 1030 or CSCI 1300, ECEN 2350	
3360	Digital Design Lab	ECEN 2350, ECEN 3350	
3400	Electromagnetic Fields	APPM 2350, ECEN 2260, PHYS 1120	
3410	Electromagnetic Waves & Transmission	ECEN 3400	Spring
3810	Introduction to Probability	APPM 2350, APPM 2360	Fall
4600/ 4620	Capstone Laboratory	ECEN 2270, 3360, 3810, & 2 (ECE) or 3 (EE) analog electives. ECEN 4593 is also required for ECE majors.	
Biomedical and Engineering			
4/5811	Neural Signals & Functional Brain Imaging	ECEN 2260	Fall
4/5821	Neural Systems & Physiological Control	ECEN 2260	Fall
Communications and Signal Processing			
4242	Communication Theory	ECEN 3300, 3810	Fall
4/5532	DSP Laboratory	ECEN 3300, 4632 (co-req)	Spring
4632	Introduction to Digital Filtering	ECEN 3300	Spring
4652	Communication Laboratory	ECEN 3300, 4242 (co-req)	Fall
Computer Engineering			
4553	Introduction to Compiler Construction	ECEN 2350, 2703	Fall
4583	Software Systems Development	CSCI 2270	
4593	Computer Organization	ECEN 3350	
4/5613	Embedded Systems Design	ECEN 3360 (3250, 4593 recommended)	
4/5623	Real-Time Embedded Systems	ECEN 3360 (4613 recommended)	Fall
4/5633	Hybrid Embedded Systems	ECEN 3360, ECEN 4593	
4/5643	SW Engineering of Concurrent Systems	ECEN 4583 or 5543	
4/5653	Real-Time Digital Media	ECEN 1030 , CSCI 3753 (see catalog for prereqs)	Spring
4/5743	SW Engineering of Distributed Systems	ECEN 4583 or 5543, (4/5643 recommended)	
Dynamics and Controls			
4138	Control Systems Analysis	ECEN 3300	Fall
4638	Control Systems Laboratory	ECEN 4138 (co-req)	Fall
Electromagnetics, RF, and Microwaves			
2420	Wireless Electronics for Communication	PHYS 1120, APPM 1360	
4/5224	High Speed Digital Design	ECEN 3400	Spring
4/5324	Microsystem Packaging	ECEN 3400, (3410 recommended)	Fall
4/5634	Microwave & RF Lab	ECEN 3410	Fall
Nanostructures and Devices			
3320	Semiconductor Devices	ECEN 3250	Fall
4/5375	Microstructures Laboratory	ECEN 3320	Spring
4/5555	Principles of Electrical Energy Systems	ECEN 3810, PHYS 2130 or 2170 (co-req)	Fall
4645	Introduction to Optical Electronics	ECEN 3410	Spring
Optics and Photonics			
4106	Photonics	ECEN 3400, 3300 (co-req)	Fall
4116	Intro to Optical Communication	ECEN 3400	Fall
4606	Optics Laboratory	ECEN 3400 or PHYS 4510, ECEN 4106 (co-req)	Fall

Prerequisites, Co-requisites, and Terms Offered

Course	*Title*	*Prerequisites and Co-requisites*	*Term offered*
4616	Optoelectronic System Design	ECEN 3400	Fall
Power Electronics and Renewable Energy Systems			
2410	Renewable Sources/Efficient Energy Syst	PHYS 1120 or ECEN 2250 (co-req)	Fall
3170	Energy Conversion 1	PHYS 1120, ECEN 3250 (co-req)	Fall
4167	Energy Conversion 2	ECEN 3170	Spring
4/5517	Renewable Power Electronics Lab	ECEN 4797	Spring
4/5797	Introduction to Power Electronics	ECEN 3250	Fall
4/5827	Analog IC Design	ECEN 3250	Fall

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.

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/

College Advising Guides — College of Engineering requirements, rules, regulations (must read).
http://ecadw.colorado.edu/engineering/students/advising.htm

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/

Registrar's Office — Deadlines, instructions for registration and drop/add, transcript requests, calendars
http://registrar.colorado.edu

Prerequisites for ECEE Program Courses

Prerequsite courses --->	APPM 1350	APPM 1360	APPM 2360	APPM 2350	PHYS 1110	PHYS 1120	ECEN 1030	CSCI 2270	ECEN 2250	ECEN 2260	ECEN 2270	ECEN 2350	ECEN 3350	ECEN 3360	ECEN 3250	ECEN 3300	ECEN 3400	ECEN 3810	ECEN 3170	ECEN 3410	ECEN 3320	ECEN 4593	ECEN 4632	ECEN 4613	ECEN 4138	ECEN 4242	Notes
ECEN 1400	C																										
ECEN 2250	X	X	C																								
ECEN 2260	X	X	X						X		C																
ECEN 2270	X	X	X						X	C																	
ECEN 2350							X																				
ECEN 2420	X	X			X	X				X																	
ECEN 2703	X	X					X																				
ECEN 3170	X	X	X		X	X			X	X					C												
ECEN 3250	X	X	X						X	X																	
ECEN 3300	X	X	X						X	X																	
ECEN 3320	X	X	X						X	X					X												
ECEN 3350							X					X															
ECEN 3360							X					X	X														
ECEN 3400	X	X	X	X	X	X			X	X																	
ECEN 3410	X	X	X	X	X	X			X	X							X										
ECEN 3810	X	X		X																							
ECEN 4106	X	X	X	X	X	X			X	X						C	X										
ECEN 4138	X	X	X						X	X						X											
ECEN 4167	X	X	X						X	X					X				X								
ECEN 4224	X	X	X	X					X	X							X										
ECEN 4242	X	X	X	X					X	X						X		X									
ECEN 4324	X	X	X	X					X	X							X			R							
ECEN 4375	X	X	X						X	X					X						X						
ECEN 4517	X	X	X						X	X					X												
ECEN 4532	X	X	X	X					X	X						X							X				
ECEN 4553	X	X					X																				*1
ECEN 4555	X	X		X	X	X												X									*S
ECEN 4583							X	X																			
ECEN 4593							X					X	X														
ECEN 4600	X	X	X	X			X		X	X	X	X	X	X	*2	*2	*2	X				E					*2
ECEN 4606	X	X	X	X	X											C	X										*3
ECEN 4613	X	X	X	X		X	X		R	R		X	X	X	R							R					
ECEN 4623	X	X	X	X		X	X					X	X	X										R			
ECEN 4632	X	X	X	X					X	X						X											
ECEN 4633	X	X	X	X			X					X	X	X								X					
ECEN 4634	X	X	X	X					X	X							X			X							
ECEN 4638	X	X	X	X					X	X						X									C		
ECEN 4645	X	X	X	X					X	X							X			X							
ECEN 4652	X	X	X	X					X	X						X		X								C	
ECEN 4653							X	X					X														*4
ECEN 4797	X	X	X	X					X	X					X												
ECEN 4811	X	X	X						X	X																	
ECEN 4821	X	X	X						X	X																	
ECEN 4827	X	X	X	X					X	X					X												
ECEN 4831	X	X	X						X	X																	

C = co-requisite	*1 = ECEN 2703
E = ECE majors only	*2 = 2 Analog Core for ECE or 3 for EE
R = recommended	*3 = may sub PHYS 4510 for ECEN 3400
S = PHYS 2130	*4 = CSCI 3750 (prereqs CSCI 2270 and ECEN 3350 or CSCI 2400)

Lab Course Schedule

Labs offered Fall semester only:

ECEN 4652 - Communication Lab / Corequisite ECEN 4242 Communication Theory
Prerequisites: ECEN 3300 Linear Systems and
ECEN 3810 Intro to Probability or approved substitute (see page 10)

ECEN 4606 - Undergrad Optics Lab / Corequisite: ECEN 4106 Photonics
Prerequisite: ECEN 3400 EM Fields & Waves

ECEN 4623 - Real-Time Embedded Systems
Prerequisites: ECEN 2350 Digital Logic and
ECEN 3350 Programming Digital Systems and
ECEN 3360 Digital Design Lab
ECEN 4613 Embedded System Design recommended

ECEN 4634 - Microwave/RF Lab / No Corequisite
Prerequisites: ECEN 3400 EM Fields & Waves and
ECEN 3410, EM Waves & Transmission (offered spring only)

ECEN 4638 - Controls Lab / Corequisite ECEN 4138 - Control Systems Analysis
Prerequisite: ECEN 3300 Linear Systems

Labs offered Spring semester only:

ECEN 4375 - Microstructures Lab (offered only in even years) / No Corequisite
Prerequisites: ECEN 3320 Semiconductor Devices (offered fall only)

ECEN 4517 - Renewable Power Electronics Lab / No Corequisite
Prerequisites: ECEN 3250 Microelectronics and
ECEN 4797 Intro to Power Electronics (offered fall only)

ECEN 4532 - Digital Signal Processing (DSP) Lab / Corequisite ECEN 4632 Intro to Digital Filtering
Prerequisites: ECEN 3300 Linear Systems and
ECEN 3810 Intro to Probability or approved substitute (see page 10)

ECEN 4653 - Real-Time Digital Media
Prerequisites: ECEN 1030 or CSCI 1300 C Programming
CSCI 3753 Operating Systems

ECEN 4837 - Mixed Signal IC Design Lab / No Corequisite
Prerequisites: ECEN 3250 Microelectronics and
ECEN 4827 Analog IC Design (offered fall only)

Labs offered both Fall and Spring semesters:

ECEN 4613 - Embedded System Design / No Corequisite
Prerequisites: ECEN 2350 Digital Logic and
ECEN 3350 Programming Digital Systems and
ECEN 3360 Digital Design Lab and
ECEN 3250 Microelectronics
ECEN 4593 Computer Organization recommended

ECEN 4633 - Hybrid Embedded Systems / No Corequisite
Prerequisites: ECEN 2350 Digital Logic and
ECEN 3350 Programming Digital Systems and
ECEN 3360 Digital Design Lab and
ECEN 4593 Computer Organization
ECEN 4613 Embedded System Design recommended

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.

Writing: 3 credit hours in one of the following upper division courses: WRTG 3030, WRTG 3035, HUEN 3100, or other writing courses as 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 any of the following eight of the eleven categories of courses in the Arts &Sciences Core found from the A&S Core Curriculum web page and through the CU Schedule Planner:
  a) Contemporary Societies
  b) Critical Thinking
  c) Culture & Gender Diversity
  d) Foreign Language
  e) Historical Context
  f) Ideals and Values
  g) Literature and the Arts
  h) United States Context

Exceptions: Critical Thinking courses taught in the following departments do NOT count for H&SS credit: ASTR, CHEM, EBIO, MATH, MCDB, PHYS.

- The College is eager to see meaningful groupings of courses in related subjects and hence will approve H&SS electives, even if they are not courses in the A&S Core, when they are grouped so as to form a coherent plan of study. Prior 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 & Sciences: Economics, Ethnic Studies, History, Linguistics, Philosophy, Political Science, Religious Studies, or Women's Studies.

- 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.

- See http://engineering.colorado.edu/homer/Fall2007.htm for assistance in selecting approved courses. Any exceptions must be approved by petition to the department.

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. Notify the ECEE Department and the Engineering Dean's Office of your intent to graduate by filling out the Application for Graduation online. Deadlines for completion of the application process will be announced by the Registrar's Office 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.

☐ 7. A graduation list is posted near the Dean's Office (AD 110) and 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 both the Dean's Office and the ECEE Undergraduate Office 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 and the Engineering Dean's Office 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. 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 sophomore term so that they can take ECEN 4138/4638 in their Fall junior 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: Semiconductor Devices, ECEN 3320
ECEN 4555 – Principles of Energy Systems & Devices
ECEN 4375 – Microstructures Laboratory (spring of odd years)

Faculty advisors: F. Barnes, G. Moddel, W. Park, 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 Physics 3 as early as possible. The stepping-off point to junior and senior-level nanostructures courses is ECEN 3250 Electronics. ECEN 3320 Semiconductor Devices and ECEN 4555 Principles of Energy Systems & Devices can be taken in any order. Semiconductor Devices must be taken before Microstructures Laboratory. ECEN 4375 Microstructures Laboratory provides hands-on experience with designing and fabricating working some of the microelectronic devices learned about in Semiconductor Devices.

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

Representative Societal Applications
- Alternative energy devices
- Nano-scale electronic devices for medical implants
- Medical imaging, cancer detection and therapeutics

Neural And Biomedical Engineering

Core prerequisite: Circuits as Systems, ECEN 2260
ECEN 4831 – Brains, Minds, and Computers
ECEN 4811 – Neural Signals and Functional Brain Imaging

Faculty advisors: F.Barnes, M.Lightner, R.Mihran, H.Wachtel

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.

Possible follow-on courses:
ECEN 4821 – Neural Systems and Physiological Control
ECEN 4011, Engineering Applications in Medicine
ECEN 4021, Design of Medical Devices

Optics and Photonics

Core prerequisite: Electromagnetic Fields and Waves, ECEN 3400 and Linear Systems, ECEN 3300
ECEN 4606 - Undergraduate Optics Lab
ECEN 4106 - Photonics or PHYS 4510 Optics, co-requisite

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 courses:
ECEN 4645 Optical Electronics
ECEN 4616 Optoelectronic Systems Design

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: R. Erickson, D. Maksimovic, R. Zane

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 – Energy Conversion I
ECEN 4167 – Energy Conversion II (co-requisite Microelectronics, ECEN 3250)

Faculty advisors: R. Erickson, D. Maksimovic, R. Zane

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 4643 Real-Time Media Design

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

ECEN 4610 Capstone Laboratory
ECEN 4033 Software Engineering of Stand-Alone Programs
ECEN 4633 Hybrid Embedded Systems
ECEN 4583 Software Systems Development

Software Engineering

Experienced software professionals work in a field that has maintained a rapid rate of change for decades making it impossible to stay current in all aspects of software engineering. Those with limited experience find that the challenges of work assignments exceed their preparation from most undergraduate degree programs. In a typical computer-related undergraduate curriculum, it is not possible to devote enough credit hours specifically to software engineering to address all of the aspects of engineering complex systems including, for example, design for maintainability, concurrency, and distributed systems. The professional certificate in software engineering covers the body of knowledge necessary to develop products more predictably and reliably for stand-alone programs as well as for software in more complex environments. The curriculum consists of three core courses:

ECEN 4033 Software Engineering of Stand-Alone Programs
or
ECEN 4583 Software Systems Development
and
ECEN 4643 Software Engineering of Concurrent Systems
ECEN 4743 Software Engineering of Distributed Systems

International Engineering Certificates

The International Engineering certificate provides Engineering students training in language, culture and engineering to be prepared to work in a global marketplace. Students take language and culture classes and do an international internship. There are certificates in French, German, Italian, Spanish, Japanese and Chinese. Please visit http://engineering.colorado.edu/academics/international.htm.

Certificate in Engineering, Science & Society and the Engineering Entrepreneurship Certificate

Information on these certificate programs may be found at 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.

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 4811/5811	Neural Signals and Functional Brain Imaging
ECEN 4821/5821	Neural Systems and Physiological Control
ECEN 4831/5831	Brains, Minds, and Computers
ECEN 40x1/50x1	Special Topics in Biomedical Engineering

For more information on the content of the BIM-ECEE courses and pre-medical studies in ECEE contact Professor Howard Wachtel, wachtel@colorado.edu, ECOT 433. 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/.

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 Dr. Sherry Snyder, Director of Student Programs and International Affairs, 303-492-5071, snyders@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 will 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.

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 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. Engineering Management courses 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. 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 with cumulative GPA between 3.75 and 3.89 at the end of the semester prior to graduation will be awarded the designation "With Distinction" on their diploma. A GPA of 3.90 or higher earns the citation "With High Distinction." At least 50 hours must have been earned at the Boulder campus and grades earned during the semester of graduation will not be considered.

Eligible students are also encouraged to participate in the College of Arts and Sciences Honors Program. Criteria for the designations of cum laude, magna cum laude, and summa cum laude are set by the Honors Council and are recorded on the student's diploma and in the commencement program. This is a separate program and both distinction and cum laude can be earned. Interested students should consult with the Director of the Engineering Honors Program for detailed information. GPA for cum laude is 3.700, for magna cum laude is 3.800 and for summa cum laude is 3.900.

Independent Study

Upper division independent study (ECEN 3840/4840) may be used as a technical elective to fulfill graduation requirements without petitioning. 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 47 of this HELP! Guide to determine the appropriate faculty member to contact. At most, 6 credit hours of independent study may be used towards a degree.

No Credit and Pass/Fail

A course taken for no credit or pass/fail cannot be used for fulfilling graduation requirements. 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.

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 (AD 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 thee 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-. See the list and chart for prerequisite courses.

Repeating Courses

A course in which a successful grade has not been received must be repeated until the appropriate grade is attained. All instances of a course will be included in the cumulative GPA. 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.

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, Professor Edward Kuester, ECOT 248, 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.

All transfer students should see the Department's Transfer Credit Evaluator, Professor Edward Kuester, ECOT 248, about acceptance of transfer credits before classes begin. (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://ecadw.colorado.edu/engineering/Advising_Guides/Intercampus_Transfer.pdf

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

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 Willard Hall, Room 34 (303-492-6541), or you may visit their website at 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/.

College of Engineering Advising Guides

These College guides, published by the Engineering Dean's office, are a series of individual sheets which cover a wide range of topics, including everything from academic honesty and ethics to scholarships to descriptions of every degree program offered in the College. They are located in a wall-mounted display near the Coffee Cafe in the Engineering Center. These guides are also available online at http://ecadw.colorado.edu/engineering/students/advising.htm

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 Willard Hall, room 134, 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 Campus Solutions. 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.

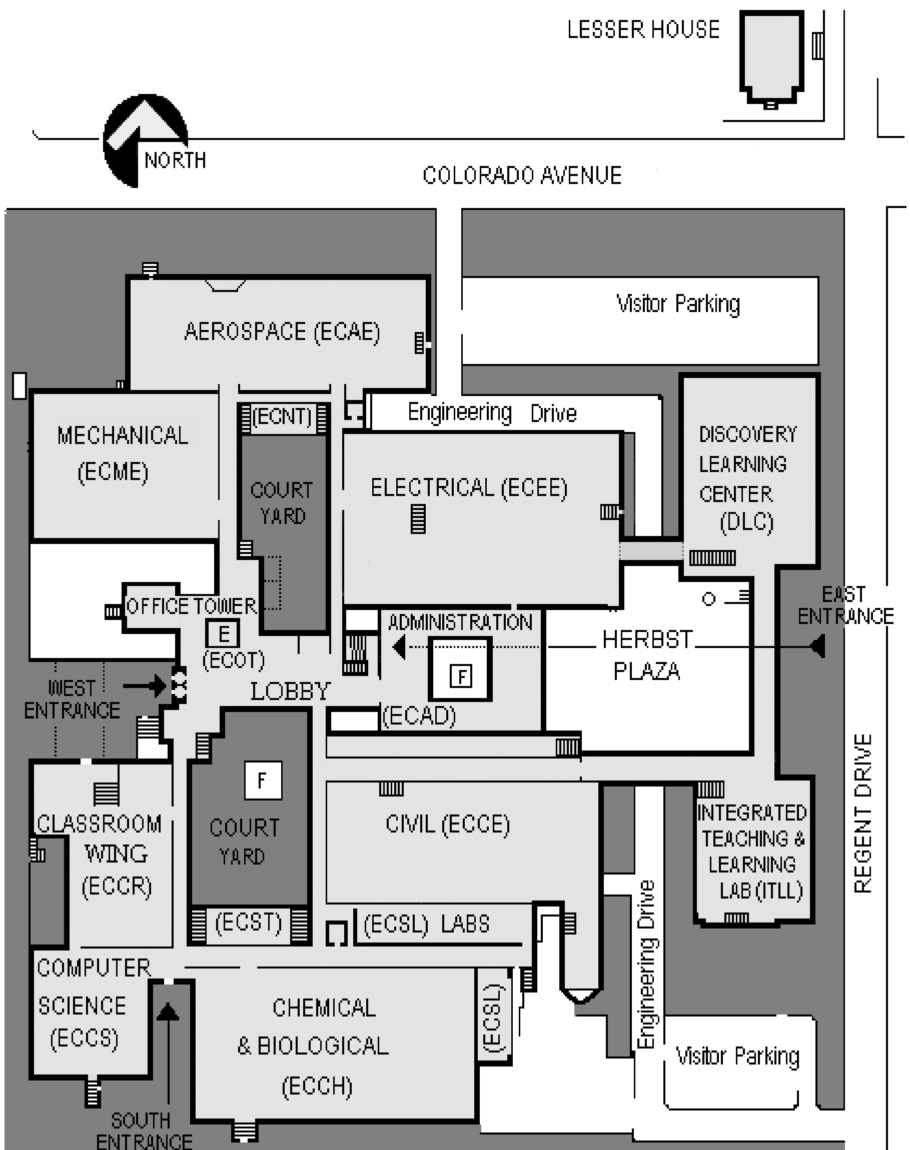
ECEE Teaching Faculty

(Area code 303)

Professor	Office	Telephone	E-mail	Area of Interest
Frank Barnes	OT 250	492-8225	barnes@colorado.edu	Bioengr, Nanostructures
Timothy Brown	OT 256	492-1630	timxb@colorado.edu	Digital Signal Process., Comm.
Thompson Brown	EE 1B22	492-4190	tomb@colorado.edu	Capstone Laboratory
Ruth Dameron	OT 435	492-8369	dameron@colorado.edu	Computer Engineering
Robert Erickson	OT 356	492-7003	rwe@colorado.edu	Power Electronics
Dejan Filipovic	OT 243	735-6319	dejan@colorado.edu	Electromagnetics
Albin Gasiewski	OT 246	492-9688	Al.Gasiewski@colorado.edu	Electromagnetics
Juliet Gopinath	EE 1B43	492-5568	Juliet.gopinath@colorado.edu	Nanostructures & Devices, Optics
John Hauser	OT 437	492-6496	hauser@colorado.edu	Dynamics & Controls
Harry Hilgers			harry.hilgers@colorado.edu	
Shannon Hughes	OT 336	492-7038	Shannon.Hughes@colorado.edu	Digital Signal Process., Comm.
Edward Kuester	OT 248	492-5173	kuester@colorado.edu	Electromagnetics
Michael Lightner	EE 1B55	492-5180	lightner@colorado.edu	VLSI/CAD
Eugene Liu	OT 337	735-6307	liue@colorado.edu	Digital Signal Process., Comm..
Dragan Maksimovic	OT 346	492-4863	maksimov@colorado.edu	Power Electronics
Jason Marden	OT 332	492-5867	jason.marden@colorado.edu	Dynamics & Controls
Peter Mathys	EE 1B67	492-7733	mathys@colorado.edu	Digital Signal Process., Comm.
Linden McClure	EE 2B37		mcclure@colorado.edu	Computer Engineering
Robert McLeod	EE 1B47	735-0997	mcleod@colorado.edu	Optics & Photonics
David Meyer	EE 1B55A	492-7158	dgm2r@colorado.edu	Dynamics & Controls
Francois Meyer	OT 340	492-5470	fmeyer@colorado.edu	Bioengr., Comm.
Alan Mickelson	EE 130	492-7539	mickel@colorado.edu	Optics, EM.
Richard Mihran	OT 436	492-8375	mihran@colorado.edu	Bioengineering
Garret Moddel	EE 148	492-1889	moddel@colorado.edu	Nanostructures & Devices
William Newhall	OT 120	735-2287	newhallw@colorado.edu	
Lucy Pao	OT 350	492-2360	pao@colorado.edu	Dynamics & Controls
Wounjhang Park	EE 248	735-3601	wpark@colorado.edu	Nanostructures & Devices
Rafael Piestun	EE 246	735-0894	piestun@colorado.edu	Optics & Photonics
Melinda Piket-May	OT 240	492-7448	mjp@colorado.edu	Electromagnetics
Andrew Pleszkun	OT 334	492-3571	arp@colorado.edu	Computer Engineering
Milos Popovic	EE 1B48	492-5304	milos.popovic@colorado.edu	Optics & Photonics
Zoya Popovic	OT 252	492-0374	zoya@colorado.edu	Electromagnetics
Li Shang	EE 197A	492-8785	Li.shang@colorado.edu	Computer Engineering
Jeremy Siek	OT 342	492-5069	Jeremy.Siek@colorado.edu	Computer Engineering
Samual Siewert		542-2508	siewerts@colorado.edu	Computer Engineering
Fabio Somenzi	OT 348	492-3466	Fabio@colorado.edu	VLSI/CAD
Bart VanZeghbroeck	EE 1B41	492-2809	bart@colorado.edu	Nanostructures & Devices
Mahesh Varanasi	OT 333	492-0258	varanasi@colorado.edu	Digital Signal Process., Comm.
Howard Wachtel	OT 433	492-7713	wachtel@colorado.edu	Bioengineering
Kelvin Wagner	EE 233	492-4661	Kelvin@colorado.edu	Optics & Photonics
Regan Zane	OT 352	735-1560	Regan.zane@colorado.edu	Power Electronics

Engineering Center Map

Engineering Center



Map= 1st Floor layout
East Entrance is on 1st Basement Floor
West & South Entrance on 1st Floor

EC= Engineering Center OT= Office Tower
NT= North Tower ST= South Tower
E= Elevator F= Fountain ▤= Stair