

ELECTRICAL ENGINEERING (ELEC)

Faculty

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Mission Statement

The rapidly changing field of electrical and computer engineering has great impact on human well-being. To meet the trust placed in our profession, students and faculty in the Electrical & Computer Engineering Department continually strive to be:

- Aware - we recognize the social and ethical dimensions of engineering.
- Engaged - we seek transformative experiences and intellectual challenges.
- Skillful - we merge knowledge with application in our professional identity.
- Articulate - we are agile communicators who effectively reach diverse audiences.
- Collaborative - we compassionately support each other to reach our full potential.
- Contemporary - we create new opportunities by designing solutions to meaningful problems.

Program Educational Objectives

Bucknell's broad, liberal education allows graduates to choose from many possible career pathways. The Electrical & Computer Engineering programs supplement this liberal education with quantitative reasoning skills and the ability to address complex, abstract problems so that in the years following graduation, Bucknell alumni...

- can utilize and adapt engineering analysis and design knowledge and skills to successfully address professional challenges across a diverse spectrum of career paths.
- are respected in their chosen field due to their professionalism, ethical grounding, effective communication skills, ability to work with others, and understanding of the broader societal contexts of engineering.
- apply their problem-solving skills and passion for lifelong learning to their chosen endeavors.
- are actively engaged with their profession and community and continue to develop professionally, socially, and personally.

The Electrical Engineering program supplements Bucknell's broad, liberal education with quantitative reasoning skills and the ability to address complex, abstract problems so that graduates can address challenging human, social, and technical problems across a range of careers. The requirements in the first two years for the **Bachelor of Science** in Electrical Engineering and **Bachelor of Science** in Computer Engineering are identical to allow students to easily switch between programs.

Bachelor of Science in Electrical Engineering

The **Bachelor of Science** in electrical engineering requirements are:

First Year

First Semester	Credits	Second Semester	Credits
ENGR 100	1	MATH 202	1
MATH 201	1	PHYS 212	1
PHYS 211	1	ECEG 100	1
Elective ^[1] (Take a W1)	1	Elective ^[1]	1
	4		4

Sophomore

First Semester	Credits	Second Semester	Credits
MATH 211	1	MATH 212 or MATH 245	1
ECEG 210	1	ECEG 270	1
ECEG 240	1	ECEG 247	1
Elective ^[1]	1	Elective ^[1]	1
		ECEG 201 (Take either Fall <u>or</u> Spring)	.5
	4 <u>or</u> 4.5		4 <u>or</u> 4.5

Junior

First Semester	Credits	Second Semester	Credits
CHEM 203 <u>or</u> PHYS 222		1 ECEG 390	1
ECEG 370		1 Core Elective 1 ^[2,3]	1
ECEG 350		1 Elective ^[1]	1
Elective ^[1]		1 Elective ^[1]	1
		ECEG 301 (Take either Fall <u>or</u> Spring)	.5
		ECEG 310 ^[2,5] (Take either Fall <u>or</u> Spring)	.5
		4.5	4.5

Senior

First Semester	Credits	Second Semester	Credits
ECEG 400 (W2)		1 ECEG 401 (W2)	1
Core Elective 2 ^[2,3]		1 Concentration Elective 2 ^[2,4]	1
Concentration Elective 1 ^[2,4]		1 Elective ^[1]	1
Elective ^[1]		1 Elective ^[1]	1
		ECEG 310 ^[2,5] (Take either Fall <u>or</u> Spring)	.5
		4 <u>or</u> 4.5	4 <u>or</u> 4.5

Total Credits: 34

Notes:

[1] A student must choose electives that meet engineering college requirements for general education (<http://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview>). At least one elective must be in either math or science. The choice of math or science electives may be determined by the concentration you choose - please consult with your adviser. Math/Science Electives are 200-level or above courses in the natural sciences (physics and astronomy, chemistry, or biology) or any of the following that are not already part of the students plan of study:

- MATH 212 Differential Equations
- MATH 241 Discrete Structures
- MATH 245 Linear Algebra
- GEOL 203 Physical/Environmental Geology
- GEOL 250 Geology for Engineers
- GEOL 334 Geophysics

[2] These courses may be taken out of the recommended sequence. The student should choose when to take these courses in consultation with their adviser taking into account plans for a concentration, study abroad, etc.

[3] Core Electives: take two of ECEG 351, ECEG 431, ECEG 461, or ECEG 472.

[4] Concentration Electives: Any 300-level or above ECEG course or courses required to complete a concentration. Independent study or honors thesis may count toward only one concentration elective. Students not pursuing a concentration should take two courses chosen in consultation with their adviser.

[5] ECEG 310 ECE Seminar must be taken twice. It is recommended that it be taken in the junior and senior years unless the student plans to study abroad.

Electrical Engineering Concentrations

Students may select a concentration—a series of electives that develops expertise in a particular sub-discipline of electrical engineering—that is recognized on the official student transcript. Only one concentration may be officially recognized. A concentration requires specific core and concentration electives, math/science electives, and up to two free electives within a particular area chosen from the lists below. Students may petition the department to consider new or other courses; the final decision is made on a case-by-case basis by the department chair in consultation with the student's adviser. Declaration of a concentration will take place in the second semester of the senior year via completion and submission of a form to the department office, due by February 15. Because not all concentration electives are offered each year, students are highly advised to discuss their interest in a concentration with their adviser no later than the end of their sophomore year. Courses used toward a minor in any department at Bucknell may not be double-counted toward a concentration. The ECE Department offers the following concentrations in electrical engineering:

Physical Electronics emphasizes the basic physical principles that underlie the operation of electronic and photonic devices and the design and application of solid state devices, solar cells, lasers, and opto-electronics. If you have an interest in merging electrical engineering with physics, this area of electrical engineering may match your interests. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
- Science Course: PHYS 222 Wave Mechanics and Quantum Physics
- M/S Elective: PHYS 309 Condensed Matter Physics
- Core electives: ECEG 351 Electronics II, ECEG 472 Digital Signals and Communications
- Concentration electives – at least two of: ECEG 492 Solid State Optoelectronic Devices, PHYS 303, PHYS 332 Quantum Mechanics, ENGR 240 Science of Materials
- Open elective restrictions: students are strongly encouraged to take at least one credit of independent study doing research.

Sustainable Energy focuses on the technology of sustainable electrical energy production and distribution including wind and solar. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
- Science Course: CHEM 203 General Chemistry for Engineers
- Core electives: ECEG 351 Electronics II, ECEG 461 Electrical Energy Conversion
- Concentration electives: ECEG 462 Renewable Energy Systems and one of: ECEG 476 Electrical Control Systems, ENGR 240 Science of Materials, or MECH 220 Mechanics
- Open elective restrictions: none

Signals and Systems prepares students for work in diverse fields such as audio/video/multimedia technology, telecommunications, smart grid technology, control systems, and machine learning. Students engage with fundamental approaches for the description and processing of quantitative information. These approaches are not only useful in the context of technical systems, but also in the context of non-technical systems such as societal, economic, and biological systems. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
- M/S Elective: MATH 245 Linear Algebra
- Core electives: ECEG 472 Digital Signals and Communications and (ECEG 351 Electronics II or ECEG 431 Computer Systems).
- Concentration electives: ECEG 470 Communication and Information Systems, ECEG 476 Electrical Control Systems, ECEG 473 Digital Speech and Audio Processing, ECEG 474 Neural Signals and Systems, or ECEG 475 Computer Communication Networking
- Open elective restrictions: none

Wireless Systems prepares students for employment or graduate study in the area of wireless systems, which includes radio frequency (RF) design, microwave and millimeter-wave systems, antennas, and digital communications. Applications include the Internet of Things; RFID; cellular, broadband, and automotive wireless networks; satellite communications; radar; remote sensing; and satellite and terrestrial-based broadcasting. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
- M/S Elective: MATH 245 Linear Algebra or MATH 350 Methods in Applied Mathematics.
- Core electives: ECEG 351 Electronics II, ECEG 472 Digital Signals and Communications.
- Concentration electives: One or both of ECEG 470 Communication and Information Systems and ECEG 497 Wireless System Design,. Any remaining concentration elective may be chosen from ECEG 475 Computer Communication Networking, ECEG 431 Computer Systems, ECEG 492 Solid State Optoelectronic Devices.
- Open elective restrictions: none

Preparation for Graduate Studies is suggested for those students who are planning to go to graduate school in electrical engineering but do not yet have a specific area they are interested in pursuing. This option provides a breadth of experience with a strong focus on the theoretical aspects of electrical engineering to serve as a basis for graduate level work. Students who wish to study a particular sub-discipline should take the concentration that best aligns with it. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
 - Science Course: CHEM 203 General Chemistry for Engineers
 - M/S Elective: MATH 245 Linear Algebra
 - Core electives: ECEG 472 Digital Signals and Communications, the other to be determined in consultation with adviser
 - Concentration electives: MATH 280 Logic, Sets, and Proofs and ECEG 495 Advanced Topics in Engineering Mathematics
 - Open elective restrictions: students are strongly encouraged to take at least one credit of independent study doing research.
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At graduation a Bucknell electrical or computer engineer:

- 1) Knows the foundational principles of engineering and the context needed to use them by demonstrating...
 - an ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics;
 - an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
- 2) Possesses the skills and abilities needed to practice electrical or computer engineering by demonstrating...
 - an ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs;
 - an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
 - an ability to communicate effectively with a range of audiences.
- 3) Possesses the professionalism and attitudes needed to be an electrical or computer engineer by demonstrating...
 - an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;
 - an ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.

Courses

ECEG 100. Foundations of Electrical and Computer Engineering. 1 Credit.

Offered Spring Semester Only; Lecture hours:3,Lab:2

Foundational concepts of electrical and computer engineering. Development of skills in simulation, testing, and programming. Introduction to electronic and computing system design principles. Students must have had or be taking MATH 201.

ECEG 101. Electrical and Computer Engineering Analysis. 1 Credit.

Offered Fall Semester Only; Lecture hours:3,Lab:2

Introduction to concepts, voltage, current, signals, network elements, and Kirchhoff's laws. Electrical measurements, energy and information generation, storage and transmission. Introduction to logic circuits and switching theory. Not for majors in electrical and computer engineering. Students must have had or be taking MATH 202.

ECEG 120. Introduction to Electrical and Computer Engineering. 1 Credit.

Offered Spring Semester Only; Lecture hours:3,Lab:2

Introduction to the fundamental concepts of electrical and computer engineering. Voltage, current, signals, electrical elements and their laws. Kirchhoff's laws and basic circuit analysis. Digital systems. Electrical measurements. Computational tools and circuit modeling software. Corequisite: MATH 202.

ECEG 201. Introduction to Electrical and Computer Engineering Design. .5 Credits.

Offered Either Fall or Spring; Lecture hours:1,Lab:2

This introductory ECE design course covers basics of electronic design focusing particularly on fabrication, measurement, and professional communication. Students will design, fabricate, and test electronic circuits and learn standards for manufacturability and professional communication.

ECEG 205. Electrical and Computer Engineering Fundamentals. 1 Credit.

Offered Both Fall and Spring; Lecture hours:3,Lab:2

Electrical measurement and physical quantities, sensors, sensor dynamics, and filters. Corequisite: MATH 202.

ECEG 210. Circuit Theory & Application. 1 Credit.

Offered Fall Semester Only; Lecture hours:3,Lab:2

Analysis and design of simple DC and AC circuits including Thevenin equivalents, time domain and sinusoidal response, power transfer, and complex impedance. Design of practical circuits and fundamentals of system integration. Prerequisite: ECEG 100.

ECEG 225. Circuit Theory I. .5 Credits.

Offered Fall Semester Only; Lecture hours:2,Lab:2

DC circuits, steady-state analysis, impedance concepts, operational amplifiers, power calculations. Corequisite: MATH 211. Prerequisite: ECEG 100 or ECEG 120 or permission of the instructor.

ECEG 226. Circuit Theory II. .5 Credits.

Offered Spring Semester Only; Lecture hours:2,Lab:2

Transformers, complex power, three-phase circuits, transients, filters, Fourier series, and Laplace transforms. Corequisite: MATH 212. Prerequisite: ECEG 225 or permission of the instructor.

ECEG 240. Digital System Design. 1 Credit.

Offered Both Fall and Spring; Lecture hours:3,Lab:2

Introduction to digital design focusing on representation and abstraction in digital systems. Prerequisite: ECEG 100 or ECEG 120 or CSCI 206.

ECEG 245. Introduction to Digital Systems. 1 Credit.**Offered Spring Semester Only; Lecture hours:3,Lab:3**

Comprehensive introduction to modern digital design techniques. Combinational and sequential logic, finite state machines, CAD tools and algorithms, and programmable logic devices. Prerequisite: ECEG 101.

ECEG 247. Embedded and Cyber-Physical Systems. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Lab:2**

Introduction to design and analysis of embedded and cyber-physical systems. Concepts include sensing, processing, decision-making, actuation, and communication. Techniques include systems modelling using various abstractions, and systems implementation using sensors, actuators, circuits, and external modules, interfacing with embedded software on microcontrollers. Prerequisites: ECEG 210 or ECEG 226 and ECEG 240.

ECEG 270. Signals and Systems Theory. 1 Credit.**Offered Spring Semester Only; Lecture hours:3,Lab:2**

Introduction to the general theory of analog systems with an emphasis on linear and time-invariant systems. Topics include elementary operator theory, Fourier/Laplace analysis, linear network analysis, elementary analog filter design, and sampling interpolation. Prerequisites: ECEG 210 or ECEG 226 and MATH 211.

ECEG 2NT. Electrical and Computer Engineering Non-traditional Study. .25-4 Credits.**Offered Fall, Spring, Summer; Lecture hours:Varies**

Non-traditional study in electrical and computer engineering. Prerequisite: permission of the instructor.

ECEG 301. Praxis of Engineering Design. .5 Credits.**Offered Both Fall and Spring; Lecture hours:1,Lab:2**

Project-oriented course that focuses on electrical and computer engineering design with the goal of developing practical skills in prototyping, professional communication, and test and measurement. Prerequisite: ECEG 201 or ECEG 226 or permission of the instructor.

ECEG 308. Independent Study. .5-1 Credits.**Offered Either Fall or Spring; Lecture hours:Varies,Other:Varies; Repeatable**

Independent study for first-year students, sophomores, and juniors. Prerequisite: permission of the instructor.

ECEG 310. ECE Seminar. .5 Credits.**Offered Either Fall or Spring; Lecture hours:2; Repeatable**

Seminar course focusing on the skills, knowledge, and mindset for successful entry into the engineering profession including interview skills, navigating the workplace, engineering ethics, the changing engineering workforce, and other current topics. ECEG 310 needs to be taken twice, preferably in each of the junior and senior years.

ECEG 320. Linear Systems and Signal Processing. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Lab:2**

Discrete and continuous signals; differential and difference equations; state equations; transform techniques (Z, Laplace, Fourier); analog and digital filter designs. Prerequisites: ECEG 226 and MATH 212.

ECEG 347. Embedded and Cyber-Physical Systems. 1 Credit.**Offered Spring Semester Only; Lecture hours:3,Lab:2**

Concepts, principles, tools, and techniques for the design, analysis, and implementation of embedded and cyber-physical systems. Integrative course that draws on topics from across the electrical and computer engineering curriculum. Prerequisites: ECEG 240 and CSCI 203, or permission of the instructor.

ECEG 350. Electronics I. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Lab:2**

Introduction to semiconductor components and circuits. Device physics, operation, and modeling; design applications of operational amplifiers, diodes, and transistors; PN junctions; digital logic gates. Prerequisite: ECEG 210 or ECEG 226 or permission of the instructor.

ECEG 351. Electronics II. 1 Credit.**Offered Spring Semester Only; Lecture hours:3,Lab:2**

Basic amplifier circuits, differential amplifiers, frequency response, and practical aspects of electronic circuit design. Prerequisite: ECEG 350 or permission of the instructor.

ECEG 370. Probabilistic System & Data Analysis. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Lab:2**

Introduction to the probabilistic description of signals, systems, and data. Topics include random variables/vectors/processes, statistical data characterization, expectations, information measures, and transformations of random data. The course includes a discussion of the foundations of detection, classification, and estimation theory. Prerequisite: ECEG 270 or ECEG 320.

ECEG 390. Theory and Applications of Electromagnetics. 1 Credit.**Offered Spring Semester Only; Lecture hours:4**

Applications of Maxwell's equations to the solution of problems involving electric and magnetic fields and transverse electromagnetic waves. Transmission line parameters, wave propagation, reflection from planar surfaces, polarization, and electromagnetic interaction with matter. Prerequisites: ECEG 210 and MATH 211.

ECEG 3NT. Electrical and Computer Engineering Non-traditional Study. .25-4 Credits.**Offered Fall, Spring, Summer; Lecture hours:Varies,Other:3**

Non-traditional study in electrical and computer engineering. Prerequisite: permission of the instructor.

ECEG 400. ECE Capstone Design I. .5-1 Credits.**Offered Fall Semester Only; Lecture hours:Varies,Other:Varies**

Engineering capstone design focusing on problem identification, project planning and logistics, and learning the divergent/convergent engineering design process in Electrical Computer Engineering. Year long capstone experience that concludes with ECEG 401. Prerequisite: ECEG 301 or permission of instructor.

ECEG 401. ECE Capstone Design II. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Other:2**

The continuation of ECEG 400 concludes the capstone sequence for electrical and computer engineering majors. Student teams develop, implement, and evaluate the value of their project for an external client. Prerequisite: ECEG 400 or permission of the instructor.

ECEG 402. Special Topics in Electrical or Computer Engineering. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Lab:2; Repeatable**

Current topics of interest in electrical or computer engineering. This course includes a lab section. Crosslisted as ECEG 602.

ECEG 403. Special Topics in Electrical and Computer Engineering. 1 Credit.**Offered Either Fall or Spring; Lecture hours:4; Repeatable**

Current topics of interest in electrical and computer engineering. This course does not include a lab section. Crosslisted as ECEG 603.

ECEG 404. Electrical and Computer Engineering Honors Thesis. .5 Credits.**Offered Fall Semester Only; Lecture hours:1.5**

Independent work on an electrical or computer engineering thesis. Prerequisites: permission of the instructor and Honors Council.

ECEG 408. Advanced Independent Study. .5-2 Credits.**Offered Either Fall or Spring; Lecture hours:Varies,Other:Varies; Repeatable**

Advanced independent study for seniors. Prerequisite: Permission of instructor.

ECEG 409. Engineering: A Humanist Enterprise. 1 Credit.**Offered Spring Semester Only; Lecture hours:3**

This course explores engineering as a human activity: undertaken by humans to meet human goals. The course explores how multiple disciplinary perspectives are required to undertake good engineering, and how our nature as humans affects engineering activities to help students transcend disciplinary boundaries. Crosslisted as UNIV 350 and ECEG 610.

ECEG 411. Neural Signals and Systems. 1 Credit.**Offered Occasionally; Lecture hours:3,Recitation:1**

Introduction to neural systems and signaling. Topics include neural physiology, models of action potential generation and synapse dynamics, neural networks and techniques of neural waveform analysis. Prerequisite: permission of the instructor. Crosslisted as BMEG 441 and ECEG 611.

ECEG 430. Mobile Computing. 1 Credit.**Offered Either Fall or Spring; Lecture hours:4**

Mobile computing ecosystem including apps, devices, wireless networks, and back-end systems. Includes at least one major project; the specific course content will vary based on projects, student interest, and current technology trends. This course typically includes a considerable amount of software development. Prerequisite: CSCI 205 or permission of instructor. Crosslisted as CSCI 340.

ECEG 431. Computer Systems. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Lab:2**

This course provides students the concepts, technologies, and skills needed for advanced study in computer engineering. It includes aspects of computer organization, computer architecture, operating systems, networking, and performance evaluation and the relationship between them. Prerequisite: CSCI 206 or ECEG 247.

ECEG 442. Digital VLSI Circuit Design. 1 Credit.**Offered Either Fall or Spring; Lecture hours:4**

Introduction to digital integrated circuit design, from wafer fabrication through structured design techniques. Teams conceptualize, design, simulate, layout, extract, and verify small VLSI systems using appropriate CAD tools. Prerequisites: ECEG 240 and ECEG 350 or permission of the instructor. Crosslisted as ECEG 642.

ECEG 443. High Performance Computer Architecture. 1 Credit.**Offered Either Fall or Spring; Lecture hours:4**

Topics include "good" computer architecture, RISC/CISC, pipelining, super-scalar, super-pipelining, out-of-order execution, speculative execution, virtual memory, and caches coherence. Prerequisites: ECEG 347, CSCI 206, or permission of the instructor.

ECEG 444. Advanced Digital Design. 1 Credit.**Offered Either Fall or Spring; Lecture hours:2,Other:2**

Design of multi-part digital systems using contemporary digital components centered around a system-on-chip with a microprocessor and FPGA. Hardware description languages, specialized FPGA elements, peripheral interfacing and protocols, high-level synthesis. Prerequisites: ECEG 240, ECEG 245, or permission of the instructor. Crosslisted as ECEG 644.

ECEG 445. Solid State Optoelectronic Devices. 1 Credit.**Offered Either Fall or Spring; Lecture hours:2,Other:2**

Basic principles required to understand the operation of solid-state devices. Semiconductor device equations developed from fundamental concepts. P-N junction theory developed and applied to the analysis of devices such as solar cells and light emitting diodes. Emphasis on device physics rather than circuit applications.

ECEG 461. Electrical Energy Conversion. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Lab:2**

Three phase power circuits, transmission and distribution systems, transformer circuits, substation equipment, rotating machines, motor generator systems and introduction to renewable power systems. Prerequisite: ECEG 350 or permission of the instructor.

ECEG 462. Renewable Energy Systems. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3**

Engineering analysis of photovoltaic, wind, and other renewable energy systems. Modeling of systems, resources, and performance with an emphasis on grid-tied photovoltaic system optimization. Open to juniors and seniors in engineering.

ECEG 463. Introduction to Mechatronics. 1 Credit.**Offered Either Fall or Spring; Lecture hours:4**

This multidisciplinary course is the synergistic integration of mechanical engineering with electronic and computer engineering. This course will study actuators, drive systems, sensors, controllers, micro- controllers programming and interfacing, and automation systems integration. Prerequisite: permission of the instructor. Crosslisted as MECH 463 and MECH 663 and ECEG 663.

ECEG 470. Communication and Information Systems. 1 Credit.**Lecture hours:3,Other:1**

Digital and analog communication systems, modulation techniques, noise considerations, optimum receivers. Prerequisite: ECEG 270 or permission of the instructor. Crosslisted as ECEG 670.

ECEG 471. Applications of Probability in Electrical and Computer Engineering. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Lab:2**

Probability theory, random variables, probability mass/density functions, expected value, Gaussian distribution, detection, estimation, applications in electrical and computer engineering. Prerequisite: ECEG 320 or permission of the instructor. Crosslisted as ECEG 671.

ECEG 472. Digital Signals and Communications. 1 Credit.**Offered Spring Semester Only; Lecture hours:3**

Introduction to digital signal processing and digital communications with an emphasis on linear and time-invariant systems. Topics: discrete time, Fourier transform (DTFT), the Fourier series, the fast Fourier transform (FFT), the z-transform, digital filters, and modulation techniques for digital signals. Prerequisite: ECEG 270 or ECEG 320 or permission of instructor. Crosslisted as ECEG 672.

ECEG 473. Digital Speech and Audio Processing. 1 Credit.**Offered Either Fall or Spring; Lecture hours:4**

Theory and application of digital speech and audio processing. Topics include speech and audio (MP3) coding, artificial speech synthesis, automatic speech recognition, and audio effects. Prerequisite: ECEG 320 or permission of the instructor. Crosslisted as ECEG 673.

ECEG 474. Neural Signals and Systems. 1 Credit.**Offered Occasionally; Lecture hours:3**

Introduction to neural systems and signaling. Topics include neural physiology, models of action potential generation and synapse dynamics, neural networks and techniques of neural waveform analysis. Prerequisite: permission of the Instructor. Crosslisted as BMEG 441.

ECEG 475. Computer Communication Networking. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3**

An introduction to computer networking using the seven-layer Open Systems Interconnection model. Hands-on exploration of the data link, network, transport, and application layers. Prerequisite: Junior status.

ECEG 476. Electrical Control Systems. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Other:2**

System components: closed loop systems; stability from Nyquist and root locus viewpoints: performance, compensation techniques, sampled systems, Z-transforms. Prerequisite: ECEG 270.

ECEG 477. Wireless System Design. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Other:2**

Introduction to hardware aspects of wireless communication systems, including RF circuit design, transmitter and receiver architecture, antennas, and radio wave propagation. Corequisite: ECEG 390 or permission of the instructor. Crosslisted as ECEG 677.

ECEG 480. Electrical Control Systems. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Lab:2**

System components: closed loop systems; stability from Nyquist and root locus viewpoints: performance, compensation techniques, sampled systems, Z-Transforms. Prerequisites: ECEG 320 and ECEG 350.

ECEG 491. Electrical Energy Conversion. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Lab:3

Three phase power circuits, transformer circuits, rotating machines and equivalent circuits, power electronic switches, machine dynamics, motor generator control. Corequisite: ECEG 390. Prerequisite: ECEG 350 or permission of the instructor.

ECEG 492. Solid State Optoelectronic Devices. 1 Credit.

Offered Either Fall or Spring; Lecture hours:2,Other:2

Basic principles of solid-state devices. Semiconductor device equations developed from fundamental concepts. PN junction theory developed and applied to the analysis of devices such as solar cells and light emitting diodes. Emphasis on device physics rather than circuit applications. Prerequisite: PHYS 212 or permission of instructor. Crosslisted as ECEG 692.

ECEG 494. Renewable Energy Systems. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3

Engineering analysis of photovoltaic, wind, and other renewable energy systems. Modeling of systems, resources, and performance with an emphasis on grid-tied photovoltaic system optimization. Open to juniors and seniors in engineering. Crosslisted as ECEG 694.

ECEG 495. Advanced Topics in Engineering Mathematics. 1 Credit.

Offered Fall Semester Only; Lecture hours:4

Linear algebra and analytical computation techniques for solving ordinary and partial differential equations relevant to engineering applications. Prerequisite: permission of the instructor. Crosslisted as CEEG 495 and CHEG 495 and MECH 495 and ENGR 695.

ECEG 497. Wireless System Design. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Other:2

Introduction to hardware aspects of wireless communication systems, including RF circuit design, transmitter and receiver architecture, antennas, and radio wave propagation. Prerequisite: ECEG 390 or permission of the instructor.