

ELECTRICAL ENGINEERING (ELEC)

Faculty

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Associate Professors: Peter M. Jansson, Amal Kabalan, David F. Kelley, Alan Marchiori, Robert M. Nickel, Michael S. Thompson (Chair)

Assistant Professor: Stewart Thomas

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Mission Statement

The rapidly changing field of electrical 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.
- Equitable - we create environments in which those from all backgrounds can succeed.
- 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 Engineering program supplements 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.

Student Outcomes

At graduation, a Bucknell electrical engineer:

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.

Possesses the skills and abilities needed to practice electrical engineering by demonstrating...

- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors;
- 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.

Possesses the professionalism and attitudes needed to be an electrical 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 a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.

The electrical engineering degree program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (<http://www.abet.org/>).

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
W1 Elective ^[1]		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 or 4.5	4 or 4.5

Junior

First Semester	Credits	Second Semester	Credits
CHEM 203 <u>or</u> PHYS 222		1 ECEG 390	1
ECEG 370		1 Selected Course 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
Selected Course 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 or 4.5	4 or 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/>). Three courses in each student's program must fulfill the University writing requirement that includes a W1 course taken in the first semester. The two subsequent W2 courses will be satisfied by senior design. 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, geology or biology) and 300-level or above mathematics courses with the exception of non-major courses, PHYS 235 Applied Electronics and MATH 303 Probability, which do **not** count as math/science electives. MATH 212 Differential Equations, MATH 241 Discrete Structures or MATH 245 Linear Algebra may be taken if they are not already part of the student's plan of study. Other courses may be substituted with permission of the department chair.

[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] Selected courses: 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 and approved by their adviser.

[5] ECEG 310 ECE Seminar must be taken twice. It is recommended that it be taken in the junior and senior years.

Information on Minors

ECEG courses that are required for the major and the two selected courses, see note [3] above, may **not** count toward a minor. Concentration electives and other electives may be counted toward a minor. Natural science and math courses, even if they are required, may be counted toward a minor.

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 selected courses 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 Feb. 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
- Math/Science Elective: CHEM 203 General Chemistry for Engineers or MATH 245 Linear Algebra.
- Selected courses: ECEG 351 Electronics II, ECEG 472 Digital Signals and Communications
- Concentration electives — at least two of: ECEG 492 Solid State Optoelectronic Devices, ENGR 240 Science of Materials, PHYS 303 Modern Optics, PHYS 309 Condensed Matter Physics, PHYS 317 Thermodynamics and Statistical Mechanics, PHYS 332 Quantum Mechanics, PHYS 336 Mathematical Methods in Physics
- Open elective recommendations: 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
- Math/Science Elective: CHEM 203 General Chemistry for Engineers
- Selected courses: ECEG 351 Electronics II, ECEG 461 Electrical Energy Conversion
- Concentration electives: ECEG 462 Renewable Energy Systems, ECEG 476 Electrical Control Systems, ECEG 492 Solid State Optoelectronic Devices, ENGR 240 Science of Materials, CEEG 242 Sustainability Principles for Engineers, CEEG 443 Sustainable Design or ENST 230 Introduction to Sustainable Design or either MECH 220 Mechanics or ENGR 229 Solid Mechanics I
- Open elective recommendations: ENST 236 Environmental Ethics, MSUS 200 Managing for Sustainability I.

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
- Math/Science Elective: MATH 245 Linear Algebra
- Selected courses: ECEG 472 Digital Signals and Communications, ECEG 351 Electronics II, 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
- Math/Science Elective: MATH 245 Linear Algebra or MATH 350 Methods in Applied Mathematics.
- Selected courses: ECEG 351 Electronics II, ECEG 472 Digital Signals and Communications.
- Concentration electives: must take ECEG 470 Communication and Information Systems and/or ECEG 497 Wireless System Design. May also take ECEG 492 Solid State Optoelectronic Devices, ECEG 431 Computer Systems.
- Open elective recommendations: CHEM 203 General Chemistry for Engineers, PHYS 222 Wave Mechanics and Quantum Physics, PHYS 221 Classical Mechanics, and ENGR 229 Solid Mechanics I.

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
- Selected courses: 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.

At graduation a Bucknell electrical 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 engineering by demonstrating...
 - an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors;
 - 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 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 a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.

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 and introduction to electronic and computing system design principles. Students develop skills in simulation, testing, and programming. 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 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. Prerequisite: permission of the instructor.

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 or permission of the instructor.

ECEG 240. Digital System Design. 1 Credit.**Offered Both Fall and Spring; Lecture hours:3,Lab:2**

Comprehensive introduction to digital logic design. Number systems, combinational logic, synchronous sequential logic, and finite state machines. Overview of programmable logic devices and hardware description languages. Synthesis and optimization of designs from high-level and abstract definitions. Prerequisite: ECEG 100 or ECEG 101 or CSCI 206 or permission of the instructor.

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

Introduces basic concepts in computer architecture, microcontroller assembly language, C programming, interrupt handling, and microcontroller interfacing. Multitasking and real-time operating systems are presented. Laboratory activities emphasize systematic debugging. Prerequisites: ECEG 210 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 and MATH 202.

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. Prerequisites: ECEG 201 or permission of the instructor.

ECEG 305. Technology as Service to Humanity. 1 Credit.**Offered Either Fall or Spring; Lecture hours:2,Other:4; Repeatable**

Team-based, technology design projects in electrical and computer engineering focusing on service to the local community. Emphasis on engineering as service to humanity through project development. Completion of 200-level ECEG courses or equivalent experience required for enrollment. Prerequisites: ECEG 270 and ECEG 247.

ECEG 308. Independent Study. .25-1 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 350. Electronics I. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Lab:2**

Introduction to semiconductor components, device physics, and modeling. Applications and practical design considerations of circuits based on operational amplifiers, diodes, voltage regulators, transistors, and CMOS logic gates. Prerequisite: ECEG 210 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.

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. 1 Credit.**Offered Fall Semester Only; Lecture hours:4,Other:2**

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 408. Advanced Independent Study. .25-2 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. Prerequisite: senior status or instructor permission. Crosslisted as UNIV 350 and ECEG 610.

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

Introduction to neural systems and engineering. Topics include neurophysiology, quantitative neural recording and stimulation models, neural signal acquisition and processing, clinical applications, and current field-wide challenges. 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, ECEG 247, or permission of the instructor.

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:3,Other:2**

Focus on memory hierarchy and parallelism in computer architecture. Concepts include RISC/CISC, pipelining, super-scalar, super-pipelining, out-of-order execution, speculative execution, virtual memory, and caches coherence, and use of hardware description languages. Prerequisites: ECEG 247 or 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 or permission of the instructor. Crosslisted as ECEG 644.

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, elements of information theory and contributions of Claude Shannon, signal space, modulation, and case studies of modern digital communication systems. Prerequisite: ECEG 270 or permission of the instructor. Crosslisted as ECEG 670.

ECEG 472. Digital Signals and Communications. 1 Credit.**Offered Spring Semester Only; Lecture hours:2,Lab:2**

Introduction to digital signal processing and digital communications. Topics: sampling theorem, discrete time Fourier transform (DTFT), Fourier series, fast Fourier transform (FFT), z-transform, digital filters, applications in audio and image processing, modulation techniques for digital signals. Prerequisite: ECEG 270 or permission of instructor. Crosslisted as ECEG 672.

ECEG 473. Digital Speech and Audio Processing. 1 Credit.**Offered Fall Semester Only; Lecture hours:4**

Theory and application of digital speech and audio processing. Topics vary, but may include audio filtering, audio coding, room acoustics, digital analysis of speech and music signals, basic concepts of electronic music, and audio effects. Prerequisite: ECEG 270 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:1**

Analysis of linear systems in time and Laplace transform domains, closed-loop transfer function, stability criteria, control system design with root locus, implementation with Arduino microcontrollers. Prerequisite: ECEG 270.

ECEG 478. Machine Learning and Intelligent Systems. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Other:2**

Introduction to artificial intelligence (AI) and machine learning (ML) including fundamental principles and creation of software applications. The course covers both practical applications and the theoretical underpinnings of ML and AI technologies. MATH 211 and Python coding experience recommended. Prerequisite: MATH 202 or permission of instructor. Crosslisted as CSCI 356 and ECEG 678.

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 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 concurrent enrollment or permission of the instructor. Crosslisted as ECEG 697.