COMPUTER ENGINEERING (CPEG)

Faculty

Professors: John C. Bravman (President), R. Alan Cheville, Richard J. Kozick, Joseph V. Tranquillo (Associate Provost for Transformative Teaching & Learning)

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

Assistant Professors: Vajiheh Farhadi, Stewart Thomas

Visiting Assistant Professor: Ali Ansari

Assistant Professor (Adjunct): Rebecca Thomas

Mission Statement

The rapidly changing field of 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.
- 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 computer 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 computer 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 computer 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 a 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 a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.

The computer engineering program at Bucknell University is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (http://www.abet.org/).

The computer engineering program supplements Bucknell's broad, liberal education with quantitative reasoning skills and the ability to address complex, abstract problems so 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 Computer Engineering** and **Bachelor of Science in Electrical Engineering** are identical to allow students to easily switch between programs.

Bachelor of Science in Computer Engineering

The **Bachelor of Science** in Computer 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
ENGR 099	0		
	4		**4**

Sophomore

First Semester	Credits	Second Semester	Credits
MATH 211	1	MATH 241 [6]	1
ECEG 210	1	ECEG 270	1
ECEG 240	1	ECEG 247	1
Elective [1]	1	Elective [1]	1
	ECEG 201 (Take either fall or spring)		0.5
	4 or 4.5		**4 or 4.5**

Junior

First Semester	Credits	Second Semester	Credits
Elective [1]	1	CSCI 205	1
ECEG 370	1	Selected Course 1 [2,3]	1
CSCI 204	1	Elective [1]	1
Elective [1]	1	Elective [1]	1
	ECEG 301 (Take either fall or spring)		.5
	ECEG 310 [2,5] (Take fall) or ECEG 311 (Take 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 fall) or ECEG 311 (Take 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 two electives must be in 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 & 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 245 Linear Algebra or MATH 212 Differential Equations may be taken if they are not already part of the student's plan of study. Other courses may be substituted with the approval of the department chair.

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

[3] Selected Courses: take two of ECEG 350, ECEG 431, ECEG 472 or CSCI 311.

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

[5] ECEG 310 and ECEG 311 must each be taken once. It is recommended that one be taken in the junior year and the other in the senior year unless the student plans to study abroad.

[6] Students interested in a mathematics minor or considering graduate studies may choose to take MATH 240 **and** MATH 280 instead of MATH 241.

Information on Minors

ECEG and CSCI 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.

Computer Engineering Concentrations

Students may select a concentration — a series of electives that develops expertise in a particular sub-discipline of computer engineering — that is recognized on the official student transcript. Only one concentration may be officially recognized. A concentration may require 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.

Concentrations must be declared to the concentration advisor by the start of the junior year. A concentration is declared by notifying the respective concentration advisor. The respective concentration advisors for each concentration are listed with the description of each concentration. Final consideration for a concentration is made via completion and submission of a Concentration Declaration Form to the department office by Feb. 15th of the senior year. Because not all concentration electives are offered each year, students are highly advised to discuss their interest in a concentration with their adviser and the concentration advisor 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 computer engineering:

Internet of Things (IoT) : captures how computing devices are embedded in nearly all products. IoT has four major areas: interaction, computation, storage and communication, and students must take one course representing each area. The areas covered by a particular course are listed with the course in the list below. Courses may only count for one area if multiple areas are listed. Prof. Stewart Thomas is the advisor for this concentration. The list below shows the courses that cover the various areas of this concentration.

- Selected courses: ECEG 350 Electronics I (computation), ECEG 431 Computer Systems (computation, storage), ECEG 472 Digital Signals and Communications (interaction, storage), CSCI 311 Algorithm Design & Analysis (computation).
- Concentration electives: ECEG 430 Mobile Computing (communication, interaction), ECEG 442 Digital VLSI Circuit Design (computation), ECEG 470 Communication and Information Systems (communication), ECEG 473 Digital Speech and Audio Processing (interaction, storage), ECEG 475 Computer Communication Networking (communication), ECEG 478 Machine Learning and Intelligent Systems (computation) ECEG 497 Wireless System Design (communication), CSCI 320 Computer Architecture (computation, storage), CSCI 341 Theory of Computation (computation). Other courses not offered on a regular basis may also count as concentration electives; please consult with your adviser.

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. Prof. Amal Kabalan is the advisor for this concentration. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
- Math/Science Electives: PHYS 222 Wave Mechanics and Quantum Physics and one of the following: CHEM 203 General Chemistry for Engineers or MATH 245 Linear Algebra.
- Selected courses: ECEG 350 Electronics I and 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, ECEG 478 Machine Learning and Intelligent Systems

- Open elective recommendations: students are strongly encouraged to take at least one credit of independent study conducting research.

Sustainable Energy: focuses on the technology of sustainable electrical energy production and distribution including wind and solar. Prof. Peter Jansson is the advisor for this concentration. This concentration has the following course requirements:

- Math/Science Electives: MATH 212 Differential Equations and CHEM 203 General Chemistry for Engineers
- Selected courses: ECEG 350 Electronics I and ECEG 461 Electrical Energy Conversion
- Concentration electives — at least two of: 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 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. Prof. Robert Nickel is the advisor for this concentration. This concentration has the following course requirements:

- Math Course: MATH 212 Differential Equations
- Math/Science Elective: MATH 245 Linear Algebra
- Selected courses — at least two of: ECEG 472 Digital Signals and Communications, ECEG 431 Computer Systems, ECEG 350 Electronics I, CSCI 311 Algorithm Design & Analysis.
- Concentration electives — at least two of: ECEG 351 Electronics II, ECEG 470 Communication and Information Systems, ECEG 476 Electrical Control Systems, ECEG 473 Digital Speech and Audio Processing, ECEG 474 Neural Signals and Systems, ECEG 475 Computer Communication Networking, ECEG 478 Machine Learning and Intelligent Systems or CSCI 365 Image Processing & Analysis.
- 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. Prof. David Kelley is the advisor for this concentration. 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 350 Electronics I and ECEG 472 Digital Signals and Communications.
- Concentration electives — at least two of: ECEG 470 Communication and Information Systems, ECEG 497 Wireless System Design, ECEG 492 Solid State Optoelectronic Devices, or ECEG 431 Computer Systems. One of the courses must be ECEG 470 or ECEG 497, or both may be taken to fulfill the requirement.
- Open elective requirements: ECEG 351 Electronics II and ECEG 390 Theory and Applications of Electromagnetics
- 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.

Formidable Challenges: prepares students to explore in depth a large societal issue that can be significantly impacted by electrical and computer engineering and focus their course of study on elective courses related to this issue. Examples could be drawn from the NAE Grand Challenges or the UN sustainable development goals and include topics such as sustainable energy, information technology and privacy, intelligent transportation, smart cities, etc. Prof. Alan Cheville is the advisor for this concentration. This concentration has the following requirements:

- Students must declare this concentration at the start of the junior year and have identified a challenge topic at that time. The department, in consultation with the student, will determine a concentration advisor for the student within the department.
- The student's concentration advisor in the department will consult with other faculty in the College of Engineering to ensure the student's work is aligned with the formidable challenge being investigated.

- Students are required to identify a second advisor outside of the College of Engineering in an area related to the formidable challenge they are investigating. The second advisor must agree to co-advise the student.
- This concentration will specify the two concentration electives and two free electives. These will be developed in concert with the student but ultimately approved by the advisors. The following additional criteria also apply.
- One concentration elective must be a one-credit independent study.
- The other concentration elective will be determined in concert with the advisors.
- Two open electives will be courses related to the issue the student is exploring and will be chosen in concert with their advisors. Earning a minor is strongly recommended to ensure sufficient depth of knowledge in a second area related to the formidable challenge.

Preparation for graduate study: consists of courses suggested for students who are planning to go to graduate school in computer engineering but do not have a specific area they want to pursue. This option provides a breadth of experience with a strong focus on the theoretical aspects of computer engineering to serve as a basis for graduate-level work. Students who have a particular interest should take the concentration that best aligns with it. Prof. Stu Thompson is the advisor for this concentration.

- Selected courses — at least two of: CSCI 311 Algorithm Design & Analysis, ECEG 431 Computer Systems, ECEG 350 Electronics I or ECEG 472 Digital Signals and Communications.
- Concentration electives — at least two of: CSCI 315 Operating Systems Design, CSCI 341 Theory of Computation, CSCI 331 Compiler Optimization, CSCI 349 Introduction to Data Mining, ECEG 443 High Performance Computer Architecture or 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 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 computer 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 a 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 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:3
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 Fall Semester Only; 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:3
Hands-on, project-focused introduction to methods of addressing open-ended design challenges in electrical and computer engineering. Emphasis on undertaking design from a systems perspective and the use of graphical, textual, and other technical representations and models in design processes. Prerequisites: ECEG 201 and 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 Fall Seminar. .5 Credits.
Offered Fall Semester Only; Lecture hours:2; Repeatable
Seminar course focusing on the skills, knowledge, and mindsets helpful in becoming a professional engineer. The course is divided into several short modules. Each module is devoted to a different topic and is taught by a different instructor. External speakers provide context for engineering practice. Taken second year or later.

ECEG 311. ECE Spring Seminar. .5 Credits.
Offered Spring Semester Only; Lecture hours:2
Seminar course focusing on the skills, knowledge, and mindsets helpful in becoming a professional engineer. The course is divided into several short modules. Each module is devoted to a different topic and is taught by a different instructor. External speakers provide context for engineering practice. Taken second year or later.

ECEG 341. Electrical & Computer Engineering Systems. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:2
This course explores the foundational concepts of electrical and computer engineering through the design and evaluation of embedded computing systems. Concepts explored will include basic electricity and circuits, digital logic, conversion of analog and digital signals, microcontroller programming and debugging, and sensor data analysis.

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 properties, differential amplifiers, frequency response, fundamentals of power electronics, 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 432. The Internet of Things. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
A broad investigation into the design of internet-connected physical objects and the infrastructure that supports them. This hands-on course covers topics including embedded systems, wireless communication, internet protocols, cloud computing and security. Students will develop their own IoT system in the course. Prerequisite: CSCI 206 or ECEG 247. Crosslisted as CSCI 332 and ECEG 632.

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:3,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.