COMPUTER ENGINEERING (CPEG)

Faculty

Professors: John C. Bravman (President), R. Alan Cheville (Chair), Richard J. Kozick, Joseph V. Tranquillo

Associate Professors: Peter M. Jansson, David F. Kelley, Robert M. Nickel, Michael S. Thompson

Assistant Professors: Amal Kabalan, Stewart Thomas

Visiting Assistant Professor: 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.
- 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 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 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
	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)	.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	Core Elective 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 either Fall or 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 or 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 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 & astronomy, chemistry, or biology), 300-level or above mathematics courses except MATH 303 Probability, or any of the following that are not already part of the student's plan of study:

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

Other courses may be substituted with permission of the department chair.

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

[3] Core Electives: take two of ECEG 350, ECEG 431, ECEG 472, or CSCI 315.

[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 their adviser.

[5] ECEG 310 must be taken twice. It is recommended to be taken in the junior and 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.

Computer Engineering Concentrations

Students may select a concentration — a series of electives that develops expertise in a particular subdiscipline of computer 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 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 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 should take one course representing each area.

- Core electives: ECEG 350 Electronics I, ECEG 431 Computer Systems (computation, storage), ECEG 472 Digital Signals and Communications (interaction, storage) CSCI 315 Operating Systems Design (computation, storage).
- Concentration electives: ECEG 430 Mobile Computing (communication), 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 497 Wireless System Design (communication), CSCI 206 Computer Organization (computation), 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.

Preparation for graduate study consists of courses suggested for those students who are planning to go to graduate school in computer engineering but do not 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 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.

- Core electives: CSCI 315 Operating Systems Design, ECEG 431 Computer Systems, or ECEG 350 Electronics I
- Concentration electives: CSCI 311 Design & Analysis of Algorithms, CSCI 341 Theory of Computation, CSCI 331 Compiler Optimization, CSCI 349 Introduction to Data Mining, 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. 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 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
Introduction to digital design focusing on representation and abstraction in digital systems. Prerequisite: ECEG 100 or ECEG 101 or CSCI 206 or permission of the instructor.

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 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 ECEG 226 and permission of the instructor.

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 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 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 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 or ECEG 347, 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: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 247 and CSCI 205, 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 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 472. Digital Signals and Communications. 1 Credit.
Offered Spring Semester Only; Lecture hours:2,Other:2
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 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. Corequisite: ECEG 390 or permission of the instructor. Crosslisted as ECEG 697.