ELECTRICAL AND BIOMEDICAL ENGINEERING

The Department of Electrical and Biomedical Engineering offers two ABET-accredited Bachelor of Science degrees:
(1) Electrical Engineering and (2) Biomedical Engineering.
Additional information on the EE and BME degrees is available in the individual program sections of this catalogue.

REGULATIONS

Students pursuing the Bachelor of Science in Electrical Engineering or the Bachelor of Science in Biomedical Engineering are subject to the Academic Standards in CEMS outlined in this catalogue.

Additional Regulations

In order to earn the Bachelor of Science in Electrical Engineering or the Bachelor of Science in Biomedical Engineering, students must achieve a minimum 2.00 GPA in all Engineering (BME, CEE, CMPE, EMGT, ENGR, EE, ME), Mathematics, Statistics, Physics, Chemistry and Computer Science coursework.

MAJORS

ELECTRICAL AND BIOMEDICAL ENGINEERING MAJORS

Biomedical Engineering B.S.BME

Electrical Engineering B.S.EE

MINORS AND CERTIFICATES

ELECTRICAL AND BIOMEDICAL ENGINEERING MINORS AND UNDERGRADUATE CERTIFICATES

Autonomy and Robotics - Undergraduate Certificate

Electrical Engineering Minor

Semiconductor Engineering and Physics - Undergraduate Certificate

Sustainable Energy Engineering Minor

GRADUATE

Biomedical Engineering AMP
Biomedical Engineering M.S.
Biomedical Engineering Ph.D.
Electrical Engineering AMP
Electrical Engineering M.S.
Electrical Engineering Ph.D.

See the online Graduate Catalogue for more information.

Biomedical Engineering Courses

BME 1600. BME Design 0. 0 or 2 Credits.
Introduction to the biodesign methodology. Hands-on design experiences that emphasize inter-disciplinary teamwork, technical communication, and engineering ethics.

BME 1605. Design 1: Intro to Design. 3 Credits.
Introduces design methodologies for biomedical engineers in a lecture format with studio-style integrated project-based learning. Integrates crucial design skills, including user-based design principles and engineering judgment, required for successful design in healthcare. Covers scientific (e.g., anatomy), engineering fundaments (e.g., physics), and hands-on prototyping skills (e.g., 3D printing, soldering, electronics prototyping, coding, etc.) relevant to the semester project. Design experiences emphasize critical thinking, interdisciplinary teamwork, technical communication, and engineering ethics. Prerequisites: Biomedical Engineering major.

BME 1990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

BME 1991. Internship. 1-3 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

BME 1993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

BME 2000. Core 1: Biomechanics & Sensing. 6 Credits.
Studio-style course that fuses lecture with project-based learning and laboratory exercises. Covers force and torque vectors, systems in equilibrium, physical properties of human body segments and biological systems, kinematics and kinetics of particles and rigid bodies, stress and strain of solid materials, circuits and instrumentation. Prerequisites: C- or better in MATH 1248, and PHYS 1500.

BME 2050. Core 2: Materials & Transport. 6 Credits.
Studio-style course that fuses lecture with project-based learning and laboratory exercises. Covers materials related to medical devices, the biological reaction to implanted medical devices, and associated failure mechanisms. Diffusive and convective mass transport in biochemical interactions, oxygen transport, cell adhesion/signaling, drug and macromolecule transport. Prerequisites: BME 2000, BHSC 1340.

BME 2170. Biomechanics. 3 Credits.
Introduces biomechanics with applications to human body dynamics and mechanics of tissues. Covers force and torque vectors, joint moments, physical properties of human body segments and biological systems, kinematics and kinetics of particles and rigid bodies, reaction loads, stress and strain of solid materials. Prerequisites: CEE 1100, ANPS 1190.

BME 2600. BME Design 1. 1 Credit.
Introduction to ISO standards, FDA, quality control, and regulatory processes. Case studies of BME Capstone Design I teams. Prerequisite: BME 1600 or equivalent.

BME 2605. Design 2: Regulatory & Testing. 3 Credits.
Introduces the regulatory, technical, and ethical contexts in which biomedical solutions are developed, tested, and approved or licensed for use in the United States, including content related to the regulatory landscape in the U.S. (e.g., regulatory history, Food and Drug Administration, regulatory pathways, design controls), technical engineering requirements (engineering specifications, risk management), testing (verification, validation, animal studies, clinical trials), and ethics. Prerequisite: BME 1605. Catamount Core: GC2.

BME 2650. BME Design 2. 1 Credit.
Introduction to verification/validation testing. Case studies of BME Capstone Design II teams. Prerequisite: BME 2600.

BME 2990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

BME 2991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

BME 2993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

BME 2994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

BME 2995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

BME 2996. College Honors. 1-6 Credits.
Honors studies leading to a thesis.

BME 3000. Core 3: Systems & Signals. 6 Credits.
Studio-style course that fuses lecture with project-based learning and Python programming. Covers continuous/discrete-time descriptions of signals, visualization and analysis of linear systems, Fourier analysis and filtering, and the collection and processing of biomedical signals. These concepts are applied to mathematical problem sets and Python programming assignments. Prerequisite: CS 1210, BME 2050. Pre/Co-requisite: MATH 3201.

BME 3130. Biomaterials. 3 Credits.
Introduces materials engineering and the biological reaction to materials in a lecture format with integrated active and project-based learning. Covers materials related to medical devices (e.g., metals, ceramics, polymers, and composites), the biological reaction to implanted medical devices (e.g., protein adsorption, wound healing, immune system reaction, failure mechanisms). Prerequisites: BHSC 1340; CHEM 1152 or CHEM 2580.

BME 3150. Biotransport. 3 Credits.
Covers fundamental topics in mass transport and fluid mechanics while focusing on applications in biomedicine. Lecture format with integrated active and project-based learning. Specific topics covered will include diffusive and convective mass transport in relation to biochemical interactions, oxygen transport, circulation, and transport of drugs and macromolecules. Prerequisites: MATH 3201, ANPS 1200.

BME 3175. Biomed Data & Signal Analysis. 4 Credits.
Introduces signal processing and system modeling for the purposes of biomedical signal and system analysis. Python programming is used to explore and apply these techniques. Covers continuous/discrete-time representations of signals, visualization and analysis of linear systems, Fourier analysis and filtering, and the collection and processing of biomedical signals. These concepts are applied in mathematical problem sets and Python programming assignments. Prerequisites: CS 1210; BME 2155 or EE 2155. Pre/co-requisite: MATH 3201.

BME 3205. Biomechanics Lab. 3 Credits.
Introduces laboratory techniques and analyses in biomechanics, focusing on human movement analysis and tissue mechanics. Covers hands-on data collection, analyses, and laboratory report writing. Prerequisite: BME 2170.

BME 3255. Biomaterials & Transport Lab. 3 Credits.
Hands-on, advanced biomedical engineering laboratory focused on applications of biomaterials and biotransport including diffusion, bioprinting, drug delivery, cell culture, protein engineering, and microfluidics. Focuses on providing students with experience and instruction in interdisciplinary teamwork, technical communication, data analysis, and experimental design. Prerequisites: BME 3130, BME 3150. Pre/Co-requisite: STAT 2430.

BME 3310. Multi-scale Biomedical Systems. 3 Credits.
Examines tissues to organs as complex systems operating at multiple levels of length and time scale. A particular focus is on how system behavior emerges in non-trivial ways from the ensemble behavior of components at lower levels of scale. Prerequisite: BME 3000.

BME 3340. Computational Systems Biology. 3 Credits.
Covers foundational mathematical models in systems biology, and their computational implementation, describing biological processes from the molecular to the ecological scale. Prerequisite: Beginner knowledge of Python programming is recommended.

BME 3370. Medical Imaging. 3 Credits.
Describes the physics behind signal acquisition and image generation for the major medical imaging modalities. Covers radiography (including diagnostic X-ray and computed tomography), magnetic resonance imaging (MRI), ultrasound, and nuclear medicine. Includes applications with image data and image processing. Prerequisites: BME 2000, BME 3000, EE 2125, or EE 2145.

BME 3410. Biomaterials Engineering. 3 Credits.
A materials science and engineering approach is used to explore the structure-function relationships of natural and bio-inspired materials for various engineering applications. The emphasis is on mechanical design and function. The medical applications of biomaterials will be discussed. Prerequisites: ME 2110 or BME 3600. Cross-listed with: ME 3410.

BME 3460. Biomechanics of Human Motion. 3 Credits.
Biomechanics of Human Motion will describe the typical processes-from small scale protein interactions to large scale joint torques-that result in human locomotion. Clinical problems and athletic performance will be discussed. Students will learn about musculoskeletal tissues related to force generation/transmission and will perform kinematic/kinetic analyses. Prerequisite: BME 2000 or ME 1120. Pre/Co-requisites: ME 2110, ME 2120, or BME 3000. Cross-listed with: ME 3460.

BME 3480. Biomechanics: Tissue Engr. 3 Credits.
Solid biomechanics including structure, function and mechanical properties of biological tissues. Tissue engineering involving cell mechanics, scaffold materials, and signaling. Current literature topics are covered. Prerequisites: ME 2110 or BME 3600. Cross-listed with: ME 3480.

BME 3600. BME Design 3. 2 Credits.
Industry-standard biodesign and project management processes. Application of principles to small-scale team-based design projects in collaboration with existing BME Capstone Design teams and to identify future Capstone projects. Shop training. Prerequisite: BME 2650.

BME 3605. Design 3: BME Capstone I. 3 Credits.
Focuses on the development of projects and prototypes in preparation for BME Capstone II in a project-based learning environment. Covers design topics (prior art, concept generation, early-stage prototyping, etc.), professional skills (project management, technical communication), and ethical design (sustainability, health equity). Prerequisite: BME 2605. Catamount Core: SU.

BME 3710. Biomedical Instrumentation. 3 Credits.
Measurement techniques for biomedical engineering research and industry, and health care institutions. Integrated biomedical monitoring, diagnostic, and therapeutic instrumentation. Prerequisite: EE 2145, EE 2175, or EE 2135. Co-requisite: EE 3110, ANPS 1200, or Instructor permission. Cross-listed with: EE 3710.

BME 3720. Biosignal Decoding. 3 Credits.
Overview of biomedical measurement techniques; development of Python software to visualize, denoise, and decode biomedical signals. Prerequisites: CS 1210; (BME 3000 or EE 3150) or (ME 2120 and EE 2845) or Instructor permission. Pre/Co-requisites: Beginner knowledge of Python programming is strongly suggested. Cross-listed with: EE 3720.

BME 3740. Wearable Sensing. 3 Credits.
Covers current state-of-the-art in wearable sensors and the biomechanical and physiological phenomena they are being used to measure. Emphasis will be given to applications related to human health and medicine. Prerequisite: EE 3150, BME 3000, or equivalent with Instructor permission.

BME 3810. Clinical Devices & Instruments. 3 Credits.
Focuses on the development, design and adaptation of biomedical devices and instruments. Team-taught by faculty in the Larner College of Medicine and UVM Medical Center and focuses on exciting active areas of biomedical device development and applications at UVM and the UVM Medical Center. Credit not awarded for both BME 3810 and BME 5800. Prerequisites: ANPS 1190, ANPS 1200; or Instructor permission.

BME 3990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

BME 3991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

BME 3993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

BME 3994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

BME 3995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

BME 4600. BME Capstone Design I. 3 Credits.
Teams apply industry-standard biodesign and project management processes to design, build, and test a functional prototype that meets their client's requirements. Prerequisite: BME 3600. Catamount Core: OC.

BME 4605. Design 4: BME Capstone II. 3 Credits.
Focuses on the development and testing of functional biomedical solutions that satisfy medical needs. Covers design topics (fabrication, verification, validation etc.), professional skills (project management, technical communication), and ethical design (sustainability, health equity). Prerequisite: BME 3605. Catamount Core: OC.

BME 4650. BME Capstone Design II. 3 Credits.
Teams refine their functional prototype from BME Capstone Design 1 and explore approaches for manufacturing at scale, regulatory strategy, clinical strategy, IP strategy, health-economics and reimbursement. Prerequisite: BME 4600.

BME 4990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

Computer Engineering Courses

CMPE 1990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CMPE 1991. Internship. 1-3 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CMPE 1993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 1994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

CMPE 1995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 1996. Honors. 1-6 Credits.
Honors course.

CMPE 2210. Computer Organization. 3 Credits.
Introduction to computer system organization including performance, assembly language, machine-level data representation, arithmetic for computers, processor datapath control, memory, and input/output. Includes significant semester project. Cross-listed with: CS 2210. Prerequisite: CS 2100.

CMPE 2810. Fundamentals of Digital Design. 0 or 4 Credits.
Combinational logic simplification and design, MSI and PLD components, synchronous and asynchronous sequential design, algorithmic state machines, registers, counters, memory units, introduction to hardware design languages. Digital circuit and system design and analysis laboratory implementation. Prerequisite: CS 1210.

CMPE 2830. Embedded Programming in C. 2-3 Credits.
Fundamental exercises in C programming for embedded systems (e.g., Arduino platform) including variable types, pointers, memory allocation, input/output, etc. and demonstration of advanced knowledge of these embedded systems concepts (second credit); with embedded systems project (third credit). Prerequisites: CS 1210. Catamount Core: QR.

CMPE 2990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CMPE 2991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CMPE 2993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 2994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

CMPE 2995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 2996. Honors. 1-6 Credits.
Honors course.

CMPE 3220. Computer Architecture. 3 Credits.
Architecture of computing systems. Control unit logic, input/output processors and devices, asynchronous processing, concurrency, parallelism, and memory hierarchies. Credit not awarded for both CMPE 3220 and CS 5220. Cross-listed with: CS 3220. Prerequisites: CMPE 2210 or CS 2210.

CMPE 3650. Computer Networks. 3 Credits.
Introduction to the theoretical and pragmatic principles and practices of computer networking. Topics include: the Internet; wired and wireless communications protocols; network security protocols. Prerequisite: CS 2240. Cross-listed with: CS 3650.

CMPE 3815. Microcontroller Systems. 0 or 4 Credits.
Operation and applications of microcontrollers in embedded digital systems for real-time control and data acquisition. Programming and the design of interfaces. Laboratory experience. Prerequisite: EE 2175, EE 2145, or EE 2125; CS 1210; EE 2810 or CMPE 2810.

CMPE 3990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CMPE 3991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CMPE 3993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 3994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

CMPE 3995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 3996. Honors. 1-6 Credits.
Honors course.

CMPE 4990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CMPE 4991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CMPE 4993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 4994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

CMPE 4995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CMPE 4996. Honors. 1-6 Credits.
Honors course.

Electrical Engineering Courses

EE 1100. EE Principles and Design. 0 or 2 Credits.
Hands-on introduction to contemporary electrical engineering principles and practice. Basic analog and digital circuit design, construction, operation, measurement. Interfacing sensors and actuators to a microcontroller, programming to interact with the world. Individual and team-based assignments that develop data dexterity and technical communication skills. Exposure to breadth of discipline and ethics in the profession. Design project. Prerequisite: First-Year students only.

EE 1990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Department permission.

EE 1991. Internship. 1-3 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

EE 1993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

EE 2125. Circuits I. 0 or 4 Credits.
Fundamental DC circuit analysis course with lab component. Topics: circuit elements and variables, integrated circuits, basic laws of circuits, method of circuit analysis. Elements of design and sensors are introduced. Prerequisite: C- or better in MATH 1248 or MATH 1242.

EE 2135. Circuits II. 0 or 4 Credits.
AC circuit analysis and advanced circuit topics with lab component. Topics: AC steady state circuit analysis using phasors, AC power and efficiency, active and passive filters, generalized circuit analysis using the Laplace transform, Fourier series decomposition. Elements of design and sensors. Prerequisite: EE 2125, EE 2175, or EE 2145.

EE 2145. Electrical Engr Concepts. 0 or 4 Credits.
Fundamentals of electrical engineering; DC and AC linear circuit analysis; laboratory component. No credit for more than one of EE 003, EE 2125, EE 2145 and EE 2175. Prerequisites: MATH 1248 or MATH 1242.

EE 2155. Electricity & Optics. 4 Credits.
Introduces the principles of electric circuits and optical systems, starting with electric charge and Coulomb's Law. Explore concepts like Gauss's Law, electric fields, and resistive networks, along with applications in device characteristics and sensor analysis. Advanced topics include AC circuits, operational amplifiers, and filter design, focusing on sensing technologies. Provides a solid understanding of electrical and optical phenomena for real-world applications in engineering. Prerequisites: MATH 1248 or MATH 1242.

EE 2175. Electrical Circuits & Sensors. 0 or 4 Credits.
Fundamentals of electrical circuits with applications to the use of sensors. DC and AC circuits. Sensors utilized for civil engineering and environmental engineering applications. Demonstrations, hands-on exercises. No credit for more than one of EE 003, EE 2125, EE 2175, EE 2145. Prerequisites: MATH 1248 or MATH 1242.

EE 2185. Circuits Design Project. 0 or 2 Credits.
Project-based course focused on the design of circuits for analog-to-digital and digital-to-analog conversion, analog computing with operational amplifiers, and filtering of signals. Advanced instrumentation, fabrication methods, and printed circuit board (PCB) layout. Prerequisite: EE 2125 or EE 2175 or EE 2145.

EE 2820. Virtual Instrument Engineering. 1-3 Credits.
Introduces logical and electrical circuit modeling using computer-based virtualization tools in a graphical format. Includes circuit simulation; scripting, interfacing; signal processing; control of instruments and data acquisition. Prerequisite: CS 1210, or Instructor permission. Cross-listed with: ENGR 2160.

EE 2845. Digital Control w/Embedded Sys. 0 or 4 Credits.
Applications of single-chip microcontrollers as embedded systems for data acquisition/real time control. C language; parallel and serial ports; timers; counters; A/D and D/A. Simple sensors and actuators. Laboratory. Prerequisites: EE 2145 or EE 2175 or EE 2125; CS 1210.

EE 2990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Department permission.

EE 2991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

EE 2993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

EE 2994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

EE 2995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

EE 2996. College Honors. 1-6 Credits.
Honors studies leading to thesis. Prerequisite: CEMS 2010.

EE 3000. Engineering Ethics/Leadership. 1 Credit.
Rights and responsibilities in engineering practice and research. Case studies related to engineering ethics. Ethics and professional practice as related to professional licensure. Development of individual leadership abilities. Team-based development of written reports and oral presentations. Prerequisite: Minimum Junior standing.

EE 3100. Electromagnetic Field Theory. 0 or 4 Credits.
Fundamentals of electromagnetic field theory and applications: vector analysis, electric and magnetic fields, potential theory, boundary conditions and boundary value problems, dielectric and magnetic material properties, conductance, capacitance, and inductance, Maxwell-Lorentz theory. Transmission line theory. Prerequisites: PHYS 1550, MATH 2248, and EE 2135.

EE 3110. Electronics I. 4 Credits.
Physical principles of operation of common semiconductor devices. Analog and digital circuits using diodes and transistors. Electronic circuit analysis and simulation. Prerequisite: PHYS 1550; EE 2135.

EE 3115. Electronics Laboratory. 0 or 2 Credits.
Characteristics and applications of semiconductor devices; inverters and logic characterization; linear amplifiers and applications of operational amplifiers in non-linear circuits. Pre/Co-requisite: EE 3110.

EE 3150. Signals & Systems. 0 or 4 Credits.
Discrete- and continuous-time signals and systems. Input/output descriptions and analysis. Convolution, Fourier analysis, sampling and Laplace transforms. Application to electrical engineering design problems. Prerequisite: MATH 3201. Pre/Co-requisite: EE 2135 recommended.

EE 3310. Low Carbon Electric Power. 3 Credits.
Greenhouse gas emission, Global Climate Change, need for low carbon electrical power. Physics and technology of three sources will be covered: photovoltaics, electrochemical systems (batteries and fuel cells) and nuclear systems, (fission and fusion). Prerequisites: PHYS 1550 or PHYS 1650.

EE 3315. Electric Energy Systems. 0 or 4 Credits.
Electrical safety; Electric power (DC, AC, single and multiphase) and transmission lines; Electric transformers; DC and AC generators; DC and AC motors; Related applications (examples: pumped hydro, HVDC transmission lines, drives); Laboratory included. Prerequisite: C- or better in EE 2135 or B- or better in EE 2145 or B- or better in EE 2175.

EE 3320. Power Electronics. 3 Credits.
An introduction to the field of power conversion using power electronics devices. Topics include Energy and Power, AC-to-DC Converters, DC-to-DC Converters, DC-to-AC Converters, Elements of Control and Design of Power Converters, Applications of Power Electronics in Renewable Energy and Microgrids. Simulations and experiments illustrate concepts. Final project related to renewable energy. Prerequisites: EE 3110 or Graduate student standing.

EE 3410. Electronics II. 4 Credits.
Physical principles of operation of common semiconductor devices. Analog and digital circuits using MOS and bipolar junction transistors. Operational amplifier design. Electronic circuit analysis and simulation. Project-based final. Prerequisite: C- or better in EE 3110.

EE 3415. Electronics Design Project. 0 or 3 Credits.
Design, analyze, simulate, build, test and document electronic circuits that meet engineering specifications. Designs follow standard requirements-based design practices. At least one project will require creating a printed wiring board layout. All projects are documented in formal reports. Focuses on building design and written communication competencies necessary for the engineering profession. Prerequisites: EE 3115, EE 3110; WIL1 course. Catamount Core: WIL2.

EE 3420. Integrated Circuit Fabrication. 0 or 4 Credits.
Science and technology of integrated circuit fabrication. Interaction of processing with material properties, electrical performance, economy, and manufacturability. Study of unit processes used to make semiconductor chips. Prerequisite: PHYS 1550 or PHYS 1650. Cross-listed with: PHYS 3165.

EE 3440. Semiconductor Materials/Devic. 0 or 4 Credits.
Covers Energy band theory, effective mass, band structure and electronic properties of semiconductors. Transport of electrons and holes in bulk materials and across interfaces. MOSFETs, BJTs, pn junctions, and Schottky barriers. Experimental portion of course will cover electronic measurements of semiconductor devices. Credit not awarded for both EE 3440 and EE 5440. Prerequisites: EE 2145, EE 3110, or PHYS 3300. Cross-listed with: PHYS 3675.

EE 3515. Control Systems. 0 or 4 Credits.
Analysis and design of control systems; stability, signal flow, performance criteria, classical methods. Analysis of control systems driven by random noise. Laboratory experiments. Credit not given for more than one of the courses EE 3515, EE 5530, ME 3320. Prerequisite: C- or better in EE 3150 or C- or better in ME 2120. Pre/Co-requisite: STAT 2430 or STAT 2510.

EE 3530. Digital Signal Processing. 3 Credits.
Covers principles and methods for digital signal processing. The analysis and design of discrete-time systems as signal processing devices is provided in the context of filter design and topics on image processing. Topics covered: quantization, reconstruction of signals, z-transform, FIR/IIR, intro to images, pixel and region-based classification and segmentation, among others. Prerequisite: EE 3150.

EE 3610. Communication Systems. 0 or 4 Credits.
Signal analysis; fundamentals of digital communications including PCM, source and channel coding, pulse shaping and modulation; wireless communications, modulation, antennas and link budgets; application of probability; related laboratory experience. Prerequisite: STAT 2510, C- or better in EE 3150.

EE 3710. Biomedical Instrumentation. 3 Credits.
Measurement techniques for biomedical engineering research and industry, and health care institutions. Integrated biomedical monitoring, diagnostic, and therapeutic instrumentation. Prerequisite: EE 2145 or EE 2135 or EE 2175. Co-requisites: EE 3110, ANPS 1200, or Instructor permission. Cross-listed with: BME 3710.

EE 3720. Biosignal Decoding. 3 Credits.
Overview of biomedical measurement techniques; development of Python software to visualize, denoise, and decode biomedical signals. Prerequisites: CS 1210; (BME 3000 or EE 3150) or (ME 2120 and EE 2845) or Instructor permission. Pre/Co-requisite: Beginner knowledge of Python programming is strongly suggested. Cross-listed with: BME 3720.

EE 3990. Special Topics. 1-18 Credits.
Special topics in developing areas of Electrical Engineering. Prerequisite: Senior standing, or Instructor permission.

EE 3991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

EE 3993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

EE 3994. Teaching Assistantship. 1-3 Credits.
Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

EE 3995. Undergraduate Research. 1-18 Credits.
Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

EE 4100. Capstone Design I. 0 or 3 Credits.
Project-based course. Multidisciplinary teams apply their knowledge to design, analyze, build and test a functional prototype that meets client's requirements and solves unique problems. Teams follow engineering design and project management processes such as periodic reports, presentations, meetings, reviews and demonstrations using standard industry tools. Prerequisite: Senior standing in Mechanical or Biomedical Engineering or Instructor permission. Cross-listed with: ME 4010.

EE 4200. Capstone Design II. 0 or 3 Credits.
Project-based course. Multidisciplinary teams apply their knowledge to design, analyze, build and test a functional prototype that meets client's requirements and solves their problems. Teams follow engineering design and project management processes such as periodic reports, presentations, meetings, reviews and demonstrations using standard industry tools. Prerequisite: EE 4100. Cross-listed with: ME 4020.