ELECTRICAL AND BIOMEDICAL ENGINEERING

The Department of Electrical & Biomedical Engineering offers an ABET-accredited Bachelor of Science in Electrical Engineering. The Bachelor of Science in Biomedical Engineering began in the Fall of 2016 with a curriculum that adheres to ABET guidelines. ABET accreditation for the BS in Biomedical Engineering is expected by Fall of 2020. 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, CE, EMGT, ENGR, EE, ME), Mathematics, Statistics, Physics, Chemistry and Computer Science coursework.

MAJORS

ELECTRICAL AND BIOMEDICAL ENGINEERING MAJORS

Biomedical Engineering B.S.BME. (http://catalogue.uvm.edu/undergraduate/engineeringandmathematicalsciences/engineering/biomedicalengineeringbs/)

Electrical Engineering B.S.EE. (http://catalogue.uvm.edu/undergraduate/engineeringandmathematicalsciences/engineering/electricalengineeringbs/)

MINORS

ELECTRICAL AND BIOMEDICAL ENGINEERING MINOR

Electrical Engineering Minor (http://catalogue.uvm.edu/undergraduate/engineeringandmathematicalsciences/engineering/electricalengineeringminor/)

GRADUATE

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

See the online Graduate Catalogue (http://catalogue.uvm.edu/graduate/) for more information.

Biomedical Engineering Courses

BME 001. Intro to Biomedical Eng Design. 0 or 2 Credits. Introduction to the biomedical engineering profession. Hands-on experiences that emphasize interdisciplinary teamwork, technical communications, and project design methodologies. Co-requisite: ENGR 002.

BME 010. BME Design 0. 0 or 2 Credits. Introduction to the biodiversity methodology. Hands-on design experiences that emphasize inter-disciplinary teamwork, technical communication, and engineering ethics.

BME 011. Core 1: Biomechanics & Sensing. 0 or 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.

BME 012. Core 2: Materials & Transport. 0 or 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. Prerequisite: BME 011.

BME 013. BME Design 1. 0 or 1 Credits. Introduction to ISO standards, FDA, quality control, and regulatory processes. Case studies of BME Capstone Design I teams. Prerequisite: BME 001 or equivalent.

BME 014. BME Design 2. 0 or 1 Credits. Introduction to verification/validation testing. Case studies of BME Capstone Design II teams. Prerequisite: BME 013.

BME 081. Biomedical Eng Lab I. 0 or 2 Credits. Laboratory experiments pertaining to biomedical instrumentation and biomechanics. Computer-based modeling of biological networks.

BME 090. 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 092. 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 096. Special Topics. 1-18 Credits. See Schedule of Courses for specific titles.
BME 111. Core 3: Systems & Signals. 0 or 6 Credits.
Studio-style course that fuses lecture with project-based learning and laboratory exercises. Covers linear modeling of biological systems with mechanical, electrical, fluidic, and thermal elements, continuous/discrete-time descriptions of signals and linear systems, fourier and Laplace analysis and feedback systems, collection and processing of signals and images. Prerequisite: BME 012.

BME 112. BME Design 3. 0 or 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 014.

BME 151. Fall BME Workshop. 0 or 1 Credits.
Seminars and lab tours to provide biomedical context to concurrently taken engineering courses. Professional development including guidance and review of resume, cover letter, and personal statement.

BME 152. Spring BME Workshop. 0 or 1 Credits.
Guest speakers and seminars to provide biomedical design examples, ethics, and insight to the biomedical engineering design process including regulatory processes.

BME 181. Biomedical Eng Lab II. 0 or 2 Credits.
Laboratory experiments including those related to biomedical sensing and instrumentation, biomechanics, tissue engineering, and/or computer-based modeling of biological networks. Prerequisite: BME 081.

BME 185. BME Capstone Design I. 0 or 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 112.

BME 186. BME Capstone Design II. 0 or 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 185.

BME 187. Capstone Design I. 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: EE 120 or EE 171, and EE 184 or Instructor permission; or Senior standing in Mechanical or Biomedical Engineering. Cross-listed with: EE 187, ME 185.

BME 188. Capstone Design II. 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: Senior standing. Cross-listed with: EE 188, ME 186.

BME 190. 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 192. 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 193. College Honors. 3-6 Credits.
Honors studies leading to a thesis. Prerequisite: CEMS 101.

BME 194. College Honors. 3-6 Credits.
Honors studies leading to a thesis. Prerequisite: BME 193.

BME 196. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

BME 197. 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 198. 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 199. Cooperative Ed Experience. 12 Credits.
On-site, full-time, supervised work experience in biomedical engineering or related field appropriate for sophomore or junior levels that also satisfies the overall educational objectives defined by the CEMS Engineering Co-op Program. Prerequisite: Sophomore or Junior; Biomedical Engineering major.

BME 206. 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: Senior or Graduate student standing in Engineering, Instructor permission. Cross-listed with: ME 206.
BME 227. 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 100 or EE 004. Co-requisite: EE 120, ANPS 020, or Instructor permission. Cross-listed with: EE 227.

BME 240. 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: ME 111 or EE 171 or equivalent with Instructor permission.

BME 241. Biomedical Signal Processing. 3 Credits.
Covers several important physiological signals often monitored in biomedical contexts (e.g., EMG, ECG, PPG). Content will include the physiology that generates the signals as well as the signal processing techniques (e.g., LTI filters, empirical mode and wavelet decomposition) and algorithms used for analysis. Prerequisite: ME 111 or EE 171 or equivalent with Instructor permission.

BME 250. Nanobiomaterials. 3 Credits.
Covers the classes of nanomaterials used biomedically, the biological response, and material testing. Content includes applications of nanomaterials in drug delivery, nano-topography of surfaces, sensors, and imaging as well as the topic of nanotoxicity. Prerequisite: ME 101 or equivalent with Instructor permission.

BME 290. 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 292. 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 296. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

BME 297. 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 298. 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.

Electrical Engineering Courses
EE 001. EE Principles and Design. 0 or 2 Credits.
Hands-on introduction to contemporary electrical engineering principles/practice. Basic analog and digital circuit design, construction, operation, measurement. Interfacing sensors and actuators to a microcontroller, programming to interact with the world. Design project.

EE 003. Linear Circuit Analysis I. 3 Credits.
Circuit elements, laws, and analysis. Network principles and theorems. Energy storage elements. Magnetically coupled circuits. Transient analysis and time constants. No credit for more than one of EE 003, EE 100 and EE 075. Prerequisite: C- or better in MATH 022 or C- or better in MATH 023. Co-requisite: PHYS 125 or PHYS 152.

EE 004. Linear Circuit Analysis II. 0 or 3 Credits.
Sinusoids and phasors. Sinusoidal steady-state response and power. Complex frequency and network functions. Resonance. Laplace transform techniques. Prerequisites: EE 003 or EE 100 or EE 075; PHYS 125 or PHYS 152.

EE 020. 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 022.

EE 021. 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 020 or (EE 003 and EE 081) or EE 075 or EE 100.

EE 075. 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 075, EE 100. Prerequisites: MATH 022 or MATH 023; CS 020 or CS 021.

EE 081. Linear Circuits Laboratory I. 0 or 2 Credits.
Electrical instruments; oscilloscope measurements; resistive, capacitive, and inductive components; applications of operational amplifiers; digital-to-analog converters; transient response of RL and RC circuits. Co-requisites: EE 003, PHYS 125.

EE 082. Linear Circuits Laboratory II. 0 or 2 Credits.
Transients in RLC circuits; steady state sinusoidal response in RLC circuits; real and reactive power in RLC circuits; operational amplifier active filters. Design project. Prerequisites: EE 081 or EE 100; PHYS 125 or PHYS 152. Co-requisite: EE 004.
EE 084. 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 020 or (EE 003 and EE 081) or EE 075 or EE 100.

EE 090. 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 092. 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 095. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Department permission.

EE 100. 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 100 and EE 075. Prerequisites: MATH 022 or MATH 023; CS 020 or CS 021.

EE 101. 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 100 or EE 003 or EE 075; CS 020 or CS 021.

EE 106. QR: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 020 or CS 021. Cross-listed with: CS 106.

EE 110. 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 110, EE 210. Prerequisite: C- or better in EE 171 or C- or better in ME 111. Co-requisite: STAT 143 or STAT 151.

EE 113. Electric Energy Systems. 0 or 4 Credits.
Energy sources, including renewables (hydro, wind, and solar PV); generation, delivery, consumption of electricity; power plants, emissions, policy; three-phase power, transformers, motors/generators; sustainability and electric energy. Laboratory included. Prerequisite: C- or better in EE 003 or B- or better in EE 100 or B- or better in EE 075.

EE 116. 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: ENGR 002 or Instructor permission. Cross-listed with: ENGR 116.

EE 120. 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: EE 004.

EE 121. 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 120.

EE 131. Fundamentals of Digital Design. 3 Credits.
Combination 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. Prerequisite: Sophomore standing.

EE 134. 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. Prerequisites: EE 003 or EE 075 or EE 100; CS 020 or CS 021; CS 031, EE 106 or CS 106.

EE 141. 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 125, MATH 271, EE 004.

EE 171. 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: EE 004 or MATH 271.
EE 174. Communication Systems. 0 or 4 Credits.
Signal analysis. Fundamentals of digital communications including PCM, channel coding, pulse shaping and modulation. Wireless communications, modulation, antennas and link budgets. Application of probability. Related laboratory experience. Prerequisite: STAT 151, C- or better in EE 171.

EE 180. 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 183. 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. Co-requisite: EE 120.

EE 184. Electronics Design Project. 0 or 3 Credits.
Electronics design project. Design, analyze, simulate, build, characterize, and test electronic circuits that address engineering applications. Designs follow standard requirements based on design practices. Introduction to printed wiring board layout and design. Prerequisite: EE 183. Co-requisite: EE 120.

EE 187. 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: EE 120 or EE 171, and EE 184 or Instructor permission; or Senior standing in Mechanical or Biomedical Engineering. Cross-listed with: BME 187, ME 185.

EE 188. 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: Senior standing. Cross-listed with: BME 188, ME 186.

EE 190. 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 192. 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 193. College Honors. 3-6 Credits.
Honors studies leading to thesis. Prerequisite: CEMS 101.

EE 194. College Honors. 3-6 Credits.
Honors studies leading to thesis. Prerequisite: EE 193.

EE 195. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Department permission.

EE 197. 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 198. 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 199. Cooperative Ed Experience. 12 Credits.
On-site, full-time, supervised work experience in electrical engineering or related field appropriate for sophomore or junior levels that also satisfies the overall educational objectives defined by the CEMS Engineering Co- op Program. Prerequisites: Electrical Engineering major; Sophomore or Junior standing.

EE 207. Intro Biomedical Engineering. 3 Credits.
Introduction to biomedical engineering science including biomechanics, biomaterials, biomedical imaging, rehabilitation engineering, biomedical computing, biomedical instrumentation, and transport phenomena. Prerequisites: Senior standing in all engineering majors other than Biomedical Engineering; Graduate Student standing with Instructor permission. Cross-listed with: ME 207.

EE 209. Transmission Line Analysis. 3 Credits.
Fourier-Laplace transform analysis of steady-state and transient phenomena on transmission lines. Phasor representation and complex variable analysis. Prerequisite: MATH 271.

EE 210. Control Systems. 3 Credits.
Analysis and design of continuous and discrete-time control systems; stability, signal flow, performance criteria, classical and state variable methods, simulation design tools, computer-based realizations. Credit not given for more than one of the courses EE 110, EE 210. Prerequisite: EE 171 or ME 111. Cross-listed with: ME 210.

EE 211. Real-Time Control Systems. 3 Credits.
Digital control systems analysis and design. Topics include: difference equations, the Z-transforms, discrete-time transfer functions, state-space models, sampled-data systems, discretization, and optimal control. Project-based final. Prerequisites: EE 110 or EE 210 or ME 210.
EE 215. Electric Energy Systems Analys. 3 Credits.
Transmission line, generator, transformer modeling and control, per-unit conversion, power flow calculations and software, symmetric components and fault analysis, protection/relaying, stability analysis, smart grid. Prerequisite: EE 113. Co-requisite: MATH 122 (preferred) or MATH 124.

EE 217. Smart Grid. 3 Credits.
Smart Grid: Using information/communication technology to modernize electric power/energy systems, including generation, transmission, distribution and consumption. Electricity physics/economics/policy; renewable energy; energy storage; demand response; energy efficiency; distributed generation; advanced metering infrastructure; distribution automation; microgrids; synchrophasors; HVDC and FACTS systems. Prerequisite: EE 113 or Graduate standing. Co-requisite: EE 215 recommended.

EE 219. 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 125 or PHYS 152.

EE 221. Digital VLSI Circuit Design. 0 or 3 Credits.
Design of VLSI circuits using a modular approach with industrial grade software: schematic capture; circuit design languages (HDL); full-custom layouts; mixed signals; synthesis. Laboratory. Prerequisites: EE 120. Pre/co-requisites: EE 131.

EE 227. 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 100 or EE 004. Co-requisites: EE 120, ANPS 020, or Instructor permission. Cross-listed with: BME 227.

EE 228. Sensors. 3 Credits.
Sensor design, interrogation, and implementation. A wide variety of electrical, electronic, optical, mechanic, and cross-disciplinary devices. System designs, measurement techniques, and methodologies. Interface electronics, system grounding and shielding methods. Prerequisite: EE 101 or EE 120.

EE 231. Digital Computer Design I. 3 Credits.
Hardware organization and realization, hard-wired and microprogrammed control units, interrupt and I/O systems. Hardware design language introduced and used for computer design. Prerequisites: EE 131; EE 134 or CS 121.

EE 232. Digital Computer Design II. 3 Credits.
Memory designs, error control, high-speed addition, multiplication, and division, floating-point arithmetic, CPU enhancements, testing and design for testability. Prerequisite: EE 231.

EE 261. Semiconductor Materials/Device. 3 Credits.
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. Prerequisite: EE 120 or Graduate Student standing.

EE 275. Digital Signal Processing. 3 Credits.
Sampling and reconstruction of signals. DFT, FFT and the z-transform. FIR and IIR filter design. Speech coding. Accompanying lab: EE 289. Pre/co-requisites: EE 171; Instructor permission.

EE 278. Wireless Communication. 3 Credits.
Modern wireless systems, including cellular design, propagation modeling, multiple access and equalization techniques. Pre/co-requisites: EE 174, STAT 151.

EE 279. Wireless Sensor Networks. 3 Credits.
Applications of and technologies behind wireless sensor networks. A systems-level perspective that integrates wireless networking, antennas, radio frequency circuitry, sensors, digital signal processing, embedded systems, and energy. Term project. Prerequisite: EE 171 or Instructor permission.

EE 290. 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 292. 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 295. Special Topics. 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 296. 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 298. 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.