

## ELECTRICAL ENGINEERING (EE)

### Courses

#### **EE 001. 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 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 020, 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 020, 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 or EE 020; 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, ME 210. Prerequisite: C- or better in EE 171 or C- or better in ME 111. Pre/Co-requisite: STAT 143 or STAT 151.

**EE 113. 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 004 or EE 021 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: CS 020, CS 021, 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: PHYS 125; EE 004 or EE 021.

**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. 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 020 or CS 021.

**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 or EE 020; CS 020 or CS 021; EE 131.

**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 121, and EE 004 or EE 021.

**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: MATH 271. Pre/Co-requisite: EE 021 recommended.

**EE 174. 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 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. Pre/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 design practices. Introduction to printed wiring board layout and design. Prerequisite: EE 183, 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 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 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, real-time control, microprocessor implementation, and optimal control. Project-based final. Prerequisites: (C+ or better in EE 110 or EE 210 or ME 210) and (EE 134 or a B- or better in EE 101).

**EE 215. Electric Energy Systems Analysis. 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 218. 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 120 or Graduate student standing.

**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 222. Analog VLSI Circuit Design. 0 or 3 Credits.**

The design, layout, and simulation of VLSI analog circuits. Emphasis on small signal models and circuits used in operational amplifiers. Prerequisites: EE 120 or Graduate student standing in Electrical Engineering or Physics.

**EE 226. RF Circuit Design. 3 Credits.**

An introduction to the design and analysis of active and passive radio frequency and microwave circuits. Topics include radio frequency and microwave circuit analysis, measurement methods, transmission line structures, matching networks, computer-aided analysis and design. Prerequisites: EE 120, EE 121.

**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 or EE 021 or EE 075. 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 229. Biosignal Decoding. 3 Credits.**

Overview of biomedical measurement techniques; development of Python software to visualize, denoise, and decode biomedical signals. Prerequisites: CS021; (BME 111 or EE 171) or (ME 111 and EE 101) or Instructor permission. Pre/Co-requisite: Beginner knowledge of Python programming is strongly suggested. Cross-listed with: BME 229.

**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 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 266. Integrated Circuit Fabrication. 3 Credits.**

Science and technology of integrated circuit fabrication. Interaction of processing with material properties, electrical performance, economy, and manufacturability. Prerequisite: EE 120. Pre/Co-requisite: EE 261 recommended.

**EE 272. Information Theory. 3 Credits.**

Introduction to probability concepts of information theory; entropy of probability models; theoretical derivations of channel capacity; coding methods and theorems, sampling theorems. Prerequisite: Graduate student standing or STAT 151.

**EE 275. 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 171.

**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.**

Special topics in developing areas of Electrical Engineering. Prerequisite: Senior standing, or Instructor permission.

**EE 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.

**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.