# Electrical and Computer Engineering

Electrical engineering is a diversified and challenging profession concerned with the design, development, fabrication, and control of the electrical devices upon which our technological society so largely depends. Electrical engineers utilize their knowledge of devices and systems design in a multitude of areas. These include electronic circuits and devices, computers, energy conversion and distribution (including novel energy sources, solar, tidal, wind), control systems (robotics), electro-optics (lasers, sensors), and communication systems (radio, TV, cellular telephones).

The curriculum provides a broad education in mathematics, the physical sciences, humanities, and social sciences. Upon this foundation is built a depth of understanding in electrical engineering and related fields. In the senior year, students may emphasize an area of interest by selecting from a broad range of electives, including a systems pair in communications, control, computers, solid state, bio-electronics or microwave/optics.

The program seeks to produce an electrical engineer who can think analytically and creatively, work effectively, and communicate clearly with others. Electrical engineering graduates may enter industry in professional engineering work or pursue advanced studies in electrical engineering or a related field, such as biomedical engineering. They may also use their electrical engineering background as the basis for further study in a different field such as law or medicine.

The curriculum, as described below, is for students entering NJIT as freshmen in the Fall of 2007 or thereafter. Students entering before that date may have a different program and should consult the department to learn which curriculum applies.

The interdisciplinary profession of computer engineering has evolved over the last decades. Computer engineering professionals develop, design, and test computer systems. They understand both computer hardware and software and possess enough engineering breadth to design computer systems for a variety of applications. Economics and Internet flexibility have led to the widespread use of computer engineering technology. The career potential for graduates with this knowledge has been strong for many years. Computer engineering consists of basic electrical engineering and computer science curricula combined with a set of special courses in computer systems. Computer engineering students will have a broad engineering background combined with in-depth knowledge of computer hardware, software, and application tradeoffs, and the basic modeling techniques representing the computing process.

The core subject areas of computer engineering are discrete mathematics, fundamentals of computing, data structures, system software and software engineering, computing languages, operating systems, logic design, digital systems design, computer architecture, interfacing and communications. Students graduating from NJIT with a Bachelor of Science in Computer Engineering and a good academic record will be able to pursue further study leading to advanced degrees in computer engineering, electrical engineering, or computer science.

The curriculum, as described below, is for students entering NJIT as freshmen in the Fall of 2007 or thereafter. Students entering before that date may have a different program and should consult the department to learn which curriculum applies.

## The Mission Statement

The Mission of the Helen and John C. Hartmann Department of Electrical and Computer Engineering at NJIT is to provide an outstanding academic and research experience to students and to prepare them to meet the needs and challenges of the 21st Century.  The mission is extended to the commitment of providing state-of-the-art interactive education through innovation, cutting-edge research with real-world experience promoting industry-university partnerships and life-long learning.

## NJIT Faculty

### A

Abdi, Ali, Professor

Akansu, Ali N., Professor

Angizi, Shaahin, Assistant Professor

Ansari, Nirwan, Distinguished Professor

### B

Bar-Ness, Yeheskel, Distinguished Professor Emeritus

### C

Carpinelli, John D., Professor

Carr, William N., Professor Emeritus

Cornely, Roy H., Professor Emeritus

## D

Dhawan, Atam P., Distinguished Professor

## F

Feknous, Mohammed, University Lecturer

Frank, Joseph Associate Professor Emeritus

Friedland, Bernard, Distinguished Professor

## G

Ge, Hongya, Associate Professor

Grebel, Haim, Professor

## H

Haddad, Richard A., Professor Emeritus

Haimovich, Alexander M., Distinguished Professor

Han, Tao, Associate Professor

Hou, Sui-Hoi Edwin, Associate Professor

Hubbi, Walid, Associate Professor

## K

Kam, Moshe, Professor and Dean of NCE

Khreishah, Abdallah, Associate Professor

Klapper, Jacob, Professor Emeritus

Kliewer, Joerg, Associate Professor

Ko, Dong-Kyun, Assistant Professor

## L

Liu, Qing, Assistant Professor

Liu, Xuan, Assistant Professor

## M

Manzhura, Oksana Yu, University Lecturer

Meyer, Andrew U., Professor Emeritus

Misra, Durgamadhab, Professor

## N

Netto, Marcos, Assistant Professor

Nguyen, Hieu, Assistant Professor

Niver, Edip, Professor

## P

Pong, Philip, Associate Professor

## R

Raj, Ratna, University Lecturer

Rojas-Cessa, Roberto, Professor

Rosenstark, Solomon, Professor Emeritus

## S

Savir, Jacob, Distinguished Professor

Shi, Yun-Qing, Professor

Sohn, Kenneth S., Professor Emeritus

Sosnowski, Marek, Professor

## T

Tsybeskov, Leonid, Professor and Chair

## W

Wang, Cong, Assistant Professor

Whitman, Gerald, Professor

## Z

Zhou, Mengchu, Distinguished Professor

Ziavras, Sotirios G., Professor

# Programs

- Computer Engineering - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/electrical-computer/computer-engineering-bs/)
- Electrical Engineering - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/electrical-computer/electrical-engineering-bs/)
- Computer Engineering Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/electrical-computer/computer-engineering-minor/) (not for Electrical Engineering or Computer Science majors)
- Computer Engineering Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/electrical-computer/computer-engineering-minor-electrical-engineering-majors/) (for Electrical Engineering majors)
- Electrical Engineering Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/electrical-computer/electrical-engineering-minor/) (not for Electrical Engineering or Computer Science majors)
- Electrical Engineering Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/electrical-computer/electrical-engineering-minor-computer-engineering-majors/) (for Computer Engineering majors)

# Electrical and Computer Engineering Courses

**ECE 101. Introduction to Electrical and Computer Engineering. 0 credits, 1 contact hour (0;0;1).**
Familiarize students with various disciplines, career opportunities and curricula in electrical and computer enginneering. Invited speakers include faculty and industrial representatives.

**ECE 231. Circuits and Systems I. 3 credits, 4 contact hours (4;0;0).**
Prerequisites: PHYS 122 and MATH 112. The basic concepts of electric circuit theory and system analysis. Topics include basic circuit elements, loop and node analysis, network theorems, sinusoidal steady-state analysis, power, resonance, mutual inductance, and ideal transformers.

**ECE 232. Circuits and Systems II. 3 credits, 4 contact hours (4;0;0).**
Prerequisite: ECE 231. Corequisite: MATH 222. A continuation of circuits and systems with special emphasis on transient response. Topics include Laplace transform analysis, transfer functions, convolution, Bode diagrams, and Fourier series.

**ECE 251. Digital Design. 3 credits, 4 contact hours (4;0;0).**
Prerequisite: PHYS 122. The design of combinational and sequential logic circuits used in digital processing systems and computers. Basic register transfer operations are covered. Topics include Boolean algebra, minimization techniques and the design of logic circuits such as adders, comparators, decoders, multiplexers, counters, arithmetic logic units, and memory systems.

**ECE 252. Microprocessors. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 251. An introduction to microprocessor system organization and assembly language programming. The course covers the architecture, instruction set and assembly language of a specific microprocessor. Other topics included are memory organization, input/output interfacing, interrupt processing as well as exception processing. The problems associated with the design of a single board computer are also covered. Students receiving degree credit for CIS 453 cannot receive degree credit for ECE 352. Co-listed as COE 252.

**ECE 271. Electronic Circuits I. 3 credits, 4 contact hours (3;0;1).**
Prerequisite: ECE 231. Corequisite: ECE 232. The electronic devices, junction diodes, bipolar transistors and field-effect transistors, are introduced and studied based on semiconductor physics models. The study then continues with analysis and design of main digital electronic circuits (NMOS and CMOS) inverters and logic gates, MOS memory and storage circuits) and with introduction to analog electronic circuits such as simple one transistor amplifiers.

**ECE 291. Electrical Engineering Laboratory I. 1 credit, 3 contact hours (0;3;0).**
Prerequisites: ECE 231, ENGL 101. Corequisites: ECE 232. Laboratory work in the areas covered in ECE 231, ECE 232. Assembling, testing and analysis of basic analog circuits. Emphasis electronic measurement techniques, instrumentation and data analysis. Simulations of dc, ac, and transient circuit response on the personal computer.

**ECE 294. Analog and Digital Circuits Laboratory. 2 credits, 4 contact hours (0;4;0).**
Prerequisites: ECE 231, ECE 251, ENGL 101. Corequisites: ECE 232. Laboratory work in the areas covered in ECE 231, ECE 232, and ECE 251. Assembling, testing and analysis of basic analog and digital circuits. Emphasis electronic measurement techniques, instrumentation and data analysis. Simulations and measurements of dc, ac, and transient response of basic analog circuits. Experiments and design of digital circuits from basic gates to complex logic, including sequential circuits, the arithmetic/logic unit, and computer memories.

**ECE 3**. ECE Technical Elective. 3 credits, 3 contact hours (3;0;0).**

**ECE 310. Co-op Work Experience I. 0 credits, 0 contact hours (0;0;0).**
Restriction: completion of the sophomore year, approval of the department, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report.

**ECE 321. Random Signals and Noise. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 232. Corequisite: ECE 333. Random processes occurring in electrical engineering. An introduction to probability and random variables is followed by stochastic processes and noise. Topics include auto- and cross-correlation functions, power spectral density, response of linear systems to random signals, and noise figure calculations.

**ECE 333. Signals and Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 232, MATH 222. A continuation of circuits and systems. Topics include signal models, system representations and properties, convolution, Fourier transform, sampling, z-transform, and an introduction to IIR and FIR filter design.

**ECE 342. Energy Conversion. 4 credits, 5 contact hours (3;2;0).**
Prerequisites: (ECE 231 and ECE 291) or (ECE 231 and ECE 294). Magnetic materials and design of singly- and multiply-excited magnetic circuits. Applications to electromechanical energy converters. Transformers, and the steady-state performance of dc and ac motors, and generators. Integrated laboratory involves experiments with ac and dc electric motors, generators, and transformers.

**ECE 353. Computer Organization and Architecture. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 252. Emphasizes the hardware design of computer systems. Topics include register transfer logic, central processing unit design, microprogramming, ALU design, pipelining, vector processing, micro-coded arithmetic algorithms, I/O organization, memory organization and multiprocessing.

**ECE 361. Electromagnetic Fields. 3 credits, 4 contact hours (3;0;1).**
Prerequisites: ECE 231, MATH 213 and MATH 222. The study of static electric and magnetic fields, basic laws of electrostatics (Coulomb’s and Gauss’s laws), scalar electric potential, electrostatic force and energy; basic laws of magnetostatics (Biot–Savart and Ampere’s laws), magnetostatic force and energy, vector magnetic potential; fundamental meaning of capacitance, resistance and inductance in terms of electric and magnetic fields. Characterization of materials (conductors, dielectrics, magnetic materials). Laws of electromagnetic fields from Poisson’s and Laplace’s to Maxwell’s equations.

**ECE 362. Electromagnetic Waves Propagation. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 361. Maxwell's equations solutions, reflection and refraction of plane waves in dielectric and conducting media, transmission lines; transients and frequency domain solutions in lossy and lossless lines, Smith chart and its applications, parallel plate and rectangular waveguides.

**ECE 368. Signal Transmission. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 232, ECE 251. This course is not for EE majors. Signal transmission both within and between digital systems. Topics include the telegrapher's equations, wave propagation, lattice diagrams, transients in digital systems, crosstalk, proper termination for high-speed logic, and the transmission characteristics of various interconnecting geometries.

**ECE 371. Electronic Circuits Design. 4 credits, 5 contact hours (3;2;0).**
Prerequisites: ECE 232, ECE 271, and ECE 294 or ECE 291. Principles of MOSFET and BJT small signal amplifiers: input and output impedance, gain, and signal range limitations. Transistor high frequency models. Feedback and frequency response of multistage amplifiers. Design of analog integrated circuits including differential amplifiers, current sources, active loads. Design and analysis of nonlinear circuits and signal generators. Simulations of these circuits are compared with the results of laboratory measurements.

**ECE 372. Electronic Circuits II. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 232, ECE 271. Principles of MOSFET and BJT small signal amplifiers: Q point design, input and output impedance, gain, and signal range limitations for different single stage configurations. Design of analog integrated circuits including differential amplifiers, current sources, active loads. Transistor high frequency models, Miller effect, and frequency response of multistage amplifiers. Feedback in multistage amplifiers. Design and analysis of nonlinear circuits based on comparators. Design and analysis of signal generators.

**ECE 374. Electronic Device I. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 271. This course addresses electronic devices on a fundamental level. Topics include semiconductors, structure and properties of p/n junction, Schottky barrier, BJT, MOS, MOS FET, semiconductor optoelectronics.

**ECE 375. Introduction to Semiconductor Devices. 4 credits, 5 contact hours (3;2;0).**
Prerequisites: (ECE 271 and ECE 291) or (ECE 271 and ECE 294). This course addresses electronic devices on a fundamental level. Topics include major semiconductor properties, p/n junction, Schottky barrier, BJT, MOSFET and optoelectronics devices. Integrated laboratory involves measurements and simulations of semiconductor device characteristics.

**ECE 381. Introduction to Applied Machine Learning. 3 credits, 4 contact hours (2;2;0).**
Restrictions: The course is open for students with junior (and above) standing. The course is composed of two main parts: 1) basic applied machine learning techniques including deep learning, regression, classification, convolutional neural networks, generative adversarial networks, and model compression; and 2) introduction to PyTorch, colab, and jupyter notebook and provide students with hands-on experience of developing and implementing machine learning solutions, on mobile and IoT devices for cyber-physical systems.

**ECE 392. Electrical Engineering Laboratory II. 2 credits, 3 contact hours (0;3;0).**
Prerequisites: ECE 271, and ECE 291. Co-requisite: ECE 372. Laboratory work in the areas covered in ECE 232, ECE 271 and ECE 372. Design, computer simulation, testing and performance analysis of analog and digital electronic circuits.

**ECE 394. Digital Systems Lab. 1 credit, 3 contact hours (0;3;0).**
Prerequisites: ECE 251, ECE 271 and ECE 291. Experiments emphasize digital design from basic electronic circuits to complex logic. Topics include switching speed, basic sequential circuits, the arithmetic/logic unit, and computer memories.

**ECE 395. Microprocessor Laboratory. 2 credits, 4 contact hours (0;4;0).**
Prerequisites: (ECE 291 and ECE 252) or (ECE 294 and ECE 252). In this laboratory the students are expected to learn to apply their theoretical knowledge of both the hardware and software aspects of microprocessors. To attain this objective the students are required to construct a microprocessor based single board computer (SBC), with adequate interfacing capabilities to be able to perform some useful control tasks. Programming of the device is done in assembly language. Some of the experiments that follow the construction project deal with software while others deal with the problems of interfacing of microprocessors.

**ECE 405. Electrical Engineering Principles. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: PHYS 121 or PHYS 122 and Junior standing. (No credit for ECE students.) For non-electrical engineering majors. Topics include basic dc and ac circuits, basic electronics, an introduction to electromechanical energy conversion and control theory.

**ECE 410. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).**
Prerequisites: ECE 310, approval of the department, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience. Mandatory participation in seminars and completion of requirements that include a report and/or project. May count as EE or approved elective. Note: Normal grading applies to this COOP Experience.

**ECE 414. Electrical and Computer Engineering Project I. 1 credit, 1 contact hour (1;0;0).**
Prerequisites: (ECE 321 and ECE 342 and (ECE 371 or (ECE 372 and ECE 392)) and ECE 395) or (ECE 353 and ECE 368 and ECE 395 and (ECE 294 or ECE 394)). With the instructor's approval, some of these courses can be taken as co-requisites. Student teams prepare and submit technical proposals for the senior design ("capstone") project to be completed the following semester in ECE 416 or ECE 417. Discussion of issues related to the engineering profession, including such topics as: intellectual property, sources of technical information, engineering codes and standards, professional organizations, professional registration. Required of all ECE students.

**ECE 416. Electrical and Computer Engineering Project II. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 414. Continuation and completion of the project based on the proposal approved in ECE 414. Progress of the project is monitored by the instructor with demonstrations and presentations at given due dates of the regularly scheduled course. An oral presentation and demonstration of the project by the student team must be given and a written report submitted at the end of the course. Successful projects are approved for the presentation at the Senior Design Project Workshop in the presence of students, faculty and industry representatives.

**ECE 417. Electrical & Computer Engineering Project II. 3 credits, 3 contact hours (0;0;3).**
Prerequisite: ECE 414. Faculty adviser approval required. Continuation and completion of the project based on the proposal approved in ECE 414 guided by a faculty or a faculty and industrial mentors with meetings scheduled as needed. A formal written report is presented to the faculty advisor at the end of the course. An oral presentation of a successful project is made at the Senior Design Project Showcase attended by students, faculty, and industry representatives.

**ECE 418. Independent Study. 3 credits, 3 contact hours (0;0;3).**
Requirements: senior standing or approval of the associate chairperson for undergraduate studies, a GPA greater than 3.0, and agreement of a faculty advisor. Provides the student with an opportunity to work on a research project under individual guidance of a faculty. The required work and intellectual challenge correspond to at least those of other senior ECE courses. A written report is required for the course completion.

**ECE 421. Digital Data Communication. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 232, MATH 333, or ECE 321. Topics include signal classification, correlation, spectral analysis, noise, signal transmission through linear systems, principles of digital data transmission, AM, FM and pulse modulations, sampling and digitalization of signals, inter-symbol interference and equalization, channel capacity, data compression techniques, error detection and correction methods.

**ECE 422. Computer Communications Networks. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 321 or MATH 333. Introduction to the fundamental concepts of computer communication networks. Topics include the OSI reference model, the physical, data link, network, and transport layers, TCP/IP, LANs (including token ring, token bus, and ethernet), ALOHA, routing and flow control.

**ECE 423. Data Communications Networking Devices. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 421 or ECE 481. Provides a working knowledge of data communication networking devices, including modems, routers, multiplexers, switches, and concentrators and are used as building blocks in the implementation, modification, or optimization of data communications networks. Emphasizes device design, functionality and physical layer protocols.

**ECE 424. Optical Communication Network. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 232 and either ECE 321 or MATH 333. Focuses on digital optical networks, architecture, modulation techniques, and detection noise. Related topics are wireless communication, infrared link, and CATV. Computer simulations of network systems are done with commercial software packages.

**ECE 425. Wireless Communication Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 481 or ECE 421. Introduction to wireless system design and engineering. Develops an understanding and appreciation of the wireless engineering problems such as cellular layout design, resource allocation, mobility management, capacity and performance and signaling load calculations. Introduces physical layer building blocks such as modulation, synchronization, coding, diversity, equalization, and spreading.

**ECE 429. Computer Communications Lab. 2 credits, 4 contact hours (0;4;0).**
Pre or Corequisites: ECE 422. Experiments with different industry-standard protocols used in the Internet and general data networks, covering the complete protocol stack, such as Data-Link layer protocols, including IEEE 802.3 variants/WiFi, Internet Protocol (IP), Transport Control Protocol (TCP), User Datagram Protocol (UDP), and practice of network design, software for network simulation, and router configuration. The exercises also cover application testing, network measurement, virtualization, and data collection for analysis.

**ECE 431. Introduction to Feedback Control Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 333, or ECE 232 and MATH 337. Concept of feedback control. Typical feedback control systems. System dynamics by Laplace transform and state space methods. Stability definition and assessment: Routh-Hurwitx criteria. Graphical stability methods: Root locus, Nyquist and Bode plots. Performance evaluation and simulation. Matlab/Simulink used extensively. A good background in Laplace transform and linear (matrix) algebra highly desirable.

**ECE 432. Advanced Control Systems and Robotics. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 431. Study of control systems with an emphasis on the modern control theories based on state space methods. Modeling and analysis of dynamic systems, feedback and feedforward control strategies, observers, and computer-based control systems. An introduction to optimal control, which is the foundation of advanced intelligent control methods such as model predictive control and reinforcement learning. The topics covered in the course are illustrated with applications in robotics.

**ECE 439. Control Systems Laboratory. 2 credits, 4 contact hours (0;4;0).**
Prerequisite: ECE 431. Laboratory work in the design and synthesis of control systems, closely coordinated with the control systems elective.

**ECE 441. Power Electronics. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 373. Electronic devices and circuits used to energize various apparatus and systems. Topics include circuits, freewheeling diodes, thyristors, firing and commutation of silicon-controlled rectifiers, converters, dc choppers, and power supplies.

**ECE 442. Power Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 341 or ECE 342. Introduction to power plants and power networks. Topics include transmission line parameters, system modeling, economic operations of power systems, load flow studies, short circuit analysis, and power system stability.

**ECE 443. Renewable Energy Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 231 and ECE 271. This course presents the various sources of renewable energy including wind, solar, and biomass as potential sources of energy and investigates the contribution they can make to the energy profile of the nation. The technology used to harness these resources will be presented. Discussions of economic,environment, and social policies are integral components of the course.

**ECE 449. Power Systems Laboratory. 2 credits, 4 contact hours (0;4;0).**
Prerequisite: ECE 442. Laboratory work in the design and synthesis of power systems, closely coordinated with the power systems elective.

**ECE 451. Advanced Computer Architecture. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 353. This course focuses on advanced concepts in computer systems design, and the interaction between hardware and software components at various levels (i.e., hardware/software codesign). It introduces common performance measures and tradeoffs used by hardware and software designers to facilitate comparative analysis. The main topics are power wall and memory wall technology challenges, pipelining, multicore architecture, advanced memory technologies with an emphasis on non-volatile memories, introduction to parallel computing, domain-specific architectures (i.e., FPGA, ASIC), and an introduction to analog and digital in-memory computing.

**ECE 452. High Performance Computer Architecture. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 451. The course focuses on recent advances and topics of current active research in the field of computer architecture. It includes new computing paradigms such as brain-inspired non-von Neumann architectures, heterogeneous computing systems, and parallel machine learning accelerator architectures. It also covers topics related to hybrid memory systems, architectures of emerging memory technologies, rowhammer and secure and reliable memory systems, and memory consistency.

**ECE 453. Introduction to Discrete Event Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 251 or CS 251 or equivalent, and MATH 333 or ECE 321 or equivalent. Introduces logical models, timed models, and stochastic timed models of discrete event systems. Applies petri net methodology to the modeling of computer systems, flexible manufacturing systems, communication networks, and robotics. Contrasts the approaches of simulation, elementary queueing theory, and Markov processes.

**ECE 459. Advanced Computer Systems Design Lab. 2 credits, 4 contact hours (0;4;0).**
Prerequisites: ECE 451, ECE 495. Corequisite: ECE 452. Design laboratory component of the advanced computer systems technical track offered to COE majors in the senior year. Experiments emphasize advanced CPU design concepts, such as RISC approaches and exception handling, multiprocessor and systolic array computers, and FPGAs. Develop software programs to test the capabilities of these hardware designs.

**ECE 461. High-Speed Devices: From RF to Optical Frequencies. 3 credits, 3 contact hours (3;0;0).**
Prerequisites: ECE 362. Concepts of wave propagation, transmission lines, optical fibers and their interface with high-speed optical modulators. High-speed semiconductor devices, amplifiers, filters and antennas. Meta-structures, phase change materials and electromagnetic shields.

**ECE 462. RF/Fiber Optics Systems Elective. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 362. Topics include dielectric waveguides and optical fibers, semiconductor optical sources and detectors; rf/microwave modulation and demodulation of an optical carrier; design concepts in optical transmitters and receivers; and usage of CAD software tools for rf/microwave simulations.

**ECE 463. Optoelectronics. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 374. The course addresses electronic and optoelectronics device concepts. Topics include optical materials, semiconductor materials, light propagination in waveguide, solar cell, LED and modulation of light.

**ECE 469. RF/Microwave and Fiber Optics Systems Laboratory. 2 credits, 4 contact hours (0;4;0).**
Corequisite: ECE 462. Laboratory work in characterization of RF/microwave transmission structures and optical fibers, sources and detectors, spectral and time domain (OTDR) measurements in micro-waves and optics. Experiments in microwave and fiber optic links. Usage of CAD software tools for RF/microwave simulations.

**ECE 475. VLSI Circuits. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 372. Topics include MOSFETs, their characteristics and use in analog and digital circuit design, static and dynamic circuits; memory cells; differential stages; symbolic layout of NMOS and CMOS circuits; fundamentals of silicon processing technology and associated design rules and methodology; calculation of chip performance including power, speed and area; logic arrays.

**ECE 481. Digital Communications Systems. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 321. An introduction to digital communications systems and modulation and techniques, along with simulation experiments of communications systems and techniques in Matlab/Simulink. Description of AM and FM modulations, sampling and digitalization of signals, baseband and carrier-modulated digital transmission, signal detection in noise, inter-symbol interference and equalization, channel capacity, data compression techniques, error detection and correction methods.

**ECE 482. Communications Systems Elective. 3 credits, 3 contact hours (3;0;0).**
Prerequisite: ECE 481. A continuation of the study of communications systems with selected topics from different areas of communications theory such as sampled-data communications, information theory and noise.

**ECE 489. Communications Systems Laboratory. 2 credits, 4 contact hours (0;4;0).**
Prerequisites: (ECE 294 and ECE 421) or (ECE 394 and ECE 421). The laboratory experiments are designed using Matlab/Simulink and Software Defined Radio (SDR). The major lab tasks include time and frequency domain analysis of AM and FM signals, generation and detection of digitally modulated waveforms such as BPSK, QPSK, 16QAM and 64QAM which are widely used in wireless communication networks. Through the experiments, students learn how to use Matlab/Simulink to control the SDR, to assess and combat the impairments due to noise and interference, and become familiar with instruments such as spectrum analyzers, audio analyzers and noise generators.

**ECE 492. Electrical Engineering Laboratory III A. 1 credit, 3 contact hours (0;3;0).**
Prerequisites: ECE 341, ECE 392. Restrictions: For Electrical Engineering majors only. A senior laboratory with experiments in power and energy conversion, including ac and dc electric motors, generators, and transformers.

**ECE 493. Electrical Engineering Laboratory III B. 1 credit, 3 contact hours (0;3;0).**
Prerequisites: ECE 374, ECE 392. Restrictions: For Electrical Engineering majors only. A senior laboratory with experiments involving semiconductor and optoelectronic devices. Characteristics of diodes, transistors, solar cells, and semiconductor sensors are measured using computer-controlled instrumentation.

**ECE 494. Electrical Engineering Laboratory III. 2 credits, 3 contact hours (1;2;0).**
Prerequisites: ECE 341, ECE 374, ECE 392. A senior laboratory with experiments in two distinct areas: A) power and energy conversion, and B)semiconductor devices. Part A involves experiments with full size ac and dc electric motors, generators, and transformers. In part B characteristics of diodes, transistors and solar cells are measured using computer controlled instrumentation.

**ECE 495. Computer Engineering Design Lab. 3 credits, 5 contact hours (1;4;0).**
Prerequisites: (ECE 294 and ECE 353) or (ECE 394 and ECE 353). Preparation for putting into practice the concepts learned in ECE 353. Emphasizes hardware design and debugging. Topics include combinational and sequential logic design using CAD tools, design based upon PLA/PLD devices, computer interface design using hardware and software, and an open-ended design project such as a central processing unit design.

**ECE 498. Special Topics in Electrical and Computer Engineering. 3 credits, 3 contact hours (3;0;0).**
The study of new and/or advanced topics in an area of electrical and computer engineering not regularly covered in any other ECE course. The precise topics to be covered in the course, along with prerequisites, will be announced in the semester prior to the offering of the course.