101 Introduction to Electrical and Computer Engineering
Fall, Spring, 1(0-3).

201 Circuits and Systems I
Fall, Spring, 3(0-3) P: (CSE 131 or concurrently) or (CSE 231 or concurrently) or (EGR 102 or concurrently) or (CSE 220 or concurrently) and ((MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently)) SA: ECE 200

202 Circuits and Systems II
Fall, Spring, 3(0-3) P: ECE 201 and ((MTH 235 or concurrently) or (MTH 255H or concurrently) or (MTH 340 or MTH 347H)) SA: ECE 360

203 Electric Circuits and Systems Laboratory
Fall, Spring, 1(0-3) P: ECE 202 or concurrently
Electrical test equipment and measurement fundamentals. Circuit and filter design using integrated circuit amplifiers.

230 Digital Logic Fundamentals
Fall, Spring, 3(0-3) P: (CSE 231 or concurrently) or (CSE 220 or concurrently) SA: ECE 301

280 Electrical Engineering Analysis
Fall, Spring, 3(0-3) P: (MTH 234 or MTH 254H) and (ECE 201 or concurrently)
Application of linear algebra, complex numbers, vectors, probability, and random processes to elementary problems in electrical and computer engineering. Application to signals, systems, noise, electromagnetics, and reliability. Modeling using standard software packages.

302 Electronic Circuits
Fall, Spring, 3(0-3) P: ECE 202 R: Open to students in the Electrical Engineering Major and open to students in the Computer Engineering Major. SA: ECE 302
Volt-ampere characteristics of diodes and transistors. Modeling using SPICE software. Differential, multistage, and integrated circuit amplifiers. High frequency effects.

303 Electronics Laboratory
Fall, Spring, 1(0-3) P: ECE 203 and (ECE 302 or concurrently) and (ECE 280 or concurrently) R: Open to students in the Department of Electrical and Computer Engineering or in the Department of Electrical and Computer Engineering. SA: EE 303
Electronic test equipment and measurement fundamentals. Circuit design using diodes, transistors, integrated circuits, and sensors.

305 Electromagnetic Fields and Waves I
Fall, Spring, Summer, 4(4-0) P: ((MTH 235 or concurrently) or (MTH 255H or concurrently) or MTH 340 or MTH 347H) and (PHY 184 or PHY 184B or PHY 234B) and (ECE 260 and (ECE 202 or concurrently)) R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 305

313 Control Systems
Fall, Spring, 3(0-3) P: (ECE 202 or ECE 345) and (ECE 280) R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 413, ECE 413
Analysis and design of control systems using transfer functions and state variable methods.

320 Energy Conversion and Power Electronics
Fall, Spring, 3(0-3) P: ECE 302 and (ECE 305 or concurrently) R: Open to students in the Electrical Engineering Major and open to students in the Computer Engineering Major. SA: EE 320

331 Microprocessors and Digital Systems
Fall, Spring, 4(3-3) P: ((EGR 102 and (CSE 251 or concurrently)) or (CSE 232 or CSE 220)) and (ECE 230 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 331

345 Electronic Instrumentation and Systems
Fall, Spring, 3(2-3) P: ((MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently)) and ((PHY 184 or PHY 184B or PHY 234B) and completion of Tier I writing requirement) R: Open to juniors or seniors in the College of Engineering. SA: EE 345
Electrical and electronic components, circuits and instruments. Circuit laws and applications, frequency response, operational amplifiers, semi-conductor devices, digital logic, counting circuits.

366 Introduction to Signal Processing
Fall, Spring, Summer, 3(3-0) P: ECE 202 and ECE 280 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: ECE 360

390 Ethics, Professionalism and Contemporary Issues
Fall, Spring, 1(1-0) P: Completion of Tier I Writing Requirement R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: ECE 384, EE 484
Ethical theories and codes of ethics. Role of the engineer in society. Contemporary issues in electrical and computer engineering. Professionalism.

402 Applications of Analog Integrated Circuits
Spring, 4(3-3) P: ECE 302 and ECE 303 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: ECE 484, EE 484
Circuit design using analog integrated circuits. SPICE macromodeling. Operational amplifiers, comparators, timers, regulators, multipliers and converters. Design project with hardware and software verification.

404 Radio Frequency Electronic Circuits
Fall, Spring, 4(3-3) P: ECE 302 and ECE 303 R: Open to students in the Department of Electrical and Computer Engineering. Radio frequency active and passive circuit design. Impedance matching for specific bandwidths. Tuned amplifier, filter, mixer, and oscillator analysis. High frequency measurements and equipment.

405 Electromagnetic Fields and Waves II
Fall, Spring, 4(3-3) P: ECE 305 R: Open to juniors or seniors or graduate students in the Computer Engineering major or in the Electrical Engineering major. SA: ECE 435

407 Electromagnetic Compatibility
Spring, 4(3-3) P: ECE 202 and ECE 305 and ECE 386 R: Open to juniors or seniors or graduate students in the Computer Engineering major or in the Electrical Engineering major. Electromagnetics for electrical systems. Signals and spectra. Regulations. Radiated and conducted emissions. Conducted and radiated immunity. Mitigation techniques.

ECE—Electrical and Computer Engineering
410  VLSI Design  Spring. 4(3-3) P: ECE 302 and ECE 303 and ECE 230 R: Open to juniors or seniors or graduate students in the College of Engineering. SA: EE 410

411  Electronic Design Automation  Fall. 4(3-3) P: CSE 320 or ECE 331 R: Open to juniors or seniors or graduate students in the College of Engineering. SA: EE 411

412  Introduction to Mixed-Signal Circuit Design  Fall. 4(3-3) P: ECE 302 R: Open to students in the Department of Electrical and Computer Engineering. SA: ECE 418

415  Computer Aided Manufacturing  Fall. 3(2-3) P: ECE 313 or ME 451 R: Open to students in the Department of Electrical and Computer Engineering. SA: EE 415
CAD/CAM fundamentals, programmable controllers, numerical control, NC part programming, sensors, data acquisition systems.

416  Digital Control  Spring. 3(2-3) P: ECE 303 and ECE 313 R: Open to juniors or seniors in the Computer Engineering major or in the Electrical Engineering major.

420  Machines and Power Laboratory  Fall. 1(3-0) P: (ECE 320 or concurrently) or (ECE 423 or concurrently) R: Open to juniors or seniors in the College of Engineering. Experimental investigation of machines, power electronics, and power systems. Experimental verification of material found in introductory courses on energy conversion with extension to power electronics and power systems.

423  Power System Analysis  Spring. 3(3-0) P: ECE 320 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: ECE 421

425  Solid State Power Conversion  Fall. 3(3-0) A student may earn a maximum of 3 credits in all enrollments for this course. P: ECE 320 and ECE 313 and (ECE 420 or concurrently) R: Open to undergraduate students in the Department of Electrical and Computer Engineering.

442  Introduction to Communication Networks  Fall. 3(3-0) P: ECE 280 or STT 351 R: Open to undergraduate students in the Department of Electrical and Computer Engineering.
Fundamental theories of communication networks with emphasis on statistical performance modeling of Medium Access Control, Data Link Control, Routing and Transport Layer protocols. Network analysis and design using basic probabilistic and statistical tools, including Little's formula, Markov Chain, and introductory queuing theory. Discrete event simulation projects.

445  Biomedical Instrumentation  Fall of even years. 3(2-3) P: ECE 303 or ECE 345 R: Open to students in the College of Engineering.

446  Biomedical Signal Processing  Fall of even years. 3(2-3) P: ECE 366 RB: Basic linear systems and probability theory. R: Open to students in the College of Engineering. Not open to students with credit in ECE 466.
Deterministic and random digital signal processing theory in the context of biomedical applications with computer projects on the analysis of real physiologic signals.

447  Introduction to Biomedical Imaging  Spring of even years. 3(3-0) P: ECE 366 RB: ECE 305 R: Open to students in the College of Engineering.
Fundamental mathematics, physics, engineering principles, and applications of biomedical imaging techniques including ultrasound, x-ray imaging, computed tomography, nuclear medicine, including PET and SPECT, and magnetic resonance imaging.

448  Modeling and Analysis of Bioelectrical Systems  Spring of odd years. 3(3-0) P: ECE 366 or ECE 313 R: Open to students in the College of Engineering.
Basics of deterministic and stochastic linear systems . Principles of biophysics and electrophysiology, Theory and principles of system identification, methods to formulate dynamic mathematical and computer models of biophysical, applications to neural systems and neuroprosthetics.

457  Communication Systems  Spring. 3(3-0) P: ECE 302 and ECE 366 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 457

458  Communication Systems Laboratory  Spring. 1(0-3) P: ECE 303 and (ECE 457 or concurrently) R: Open to students in the Department of Electrical and Computer Engineering.
A projects laboratory in communication systems.

466  Digital Signal Processing and Filter Design  Fall. 3(3-0) P: ECE 366 R: Open to seniors or graduate students in the College of Engineering. SA: EE 466 Not open to students with credit in ECE 446.

474  Principles of Electronic Devices  Spring. 3(3-0) P: ECE 302 and ECE 305 R: Open to seniors or graduate students in the College of Engineering.
Energy levels in atoms. Crystal properties, energy bands and charge carriers, semiconductors, transport properties of bulk materials. P-n junction diodes, bipolar transistors, field effect transistors.

476  Electro-Optics  Fall. Summer. 4(3-3) P: ECE 302 and ECE 303 and ECE 305 R: Open to juniors or seniors in the Department of Electrical and Computer Engineering major or in the Electrical Engineering major. SA: EE 476
Operational theory, characteristics and applications of optical components, light emitting diodes, lasers, laser diodes, photodetectors, photovoltaics, fiber optics, optical modulators and non-linear optical devices.

477  Microelectronic Fabrication  Fall. 3(2-3) P: (ECE 474 or concurrently) and ECE 303 R: Open to juniors or seniors in the College of Engineering. SA: ECE 483
Microelectronic processing fundamentals and simulations. Comparison of current microfabrication technologies and their limitations.

480  Senior Design  Fall. Spring, 4(3-3) P: (ECE 303 and ECE 313 and ECE 320 and ECE 331 and ECE 366 and (ECE 390 or concurrently)) or ((ECE 410 and (ECE 390 or concurrently)) and completion of Tier I writing requirement) R: Open to seniors in the Department of Electrical and Computer Engineering or in the College of Engineering.
Electrical engineering and computer engineering senior design experience involving contemporary design tools and practices, engineering standards, cross-functional teams, oral and written technical communication, and lifelong learning.

490  Independent Study  Fall, Spring. Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. SA: EE 490
Independent study of a topic in electrical engineering or computer engineering.
810 Radio Frequency Integrated Circuits
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. SA: EE 498
Investigation of special topics in electrical engineering or computer engineering.

491 Special Topics
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open to students in the College of Engineering. SA: EE 499
Investigation of special topics in electrical engineering or computer engineering.

499 Undergraduate Research
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Approval of department. SA: EE 499
Independent undergraduate research in contemporary areas of electrical engineering or computer engineering.

801 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. SA: EE 802
Independent investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

802 Selected Topics
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 21 credits in all enrollments for this course. SA: EE 802
Investigation of special topics in electrical engineering.

810 Radio Frequency Integrated Circuits
Fall. 3(3-0) RB: Electrical and Computer Engineering and Computer Science and Engineering.
Transceiver architecture designs with emphasis on hardware building blocks. Integrated radio frequency designs for various communication standards. Basic building blocks including low noise and power amplifiers, mixers, voltage control oscillators, and frequency synthesizers. Integrated circuit designs of basic building blocks.

813 Advanced VLSI Design
Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. P: ECE 410 SA: EE 813

814 Embedded Wireless RF Transceivers
Fall of even years. 3(3-0)
Transceiver architecture designs. Software components. Realtime computing and synchronization on digital signal processing platforms, embedded software transceivers, receiver hardware and software considerations, signal structures and CDMA codes, real-time acquisitions and tracking, synchronization, software receivers.

816 Cryptography and Network Security
Spring of even years. 3(3-0)
Major security techniques, including authenticity, confidentiality, message integrity, non-repudiation, and the mechanisms to achieve them. Network security and system security practices, including authentication practice, e-mail security, IP security, Web security, and firewalls.

818 Robotics
Spring. 3(3-0) RB: ECE 313 or ME 451 R: Open only to graduate students in the College of Engineering.
Robot modeling, kinematics, dynamics, trajectory planning, programming, sensors, controller design.

819 Smart Material Sensors and Actuators
Fall of odd years. 3(3-0) RB: General background in mechanics, dynamics, and control systems at the undergraduate level is desirable although not required. Fundamentals of piezoelectric materials, magnetostrictive materials, shape memory alloys, electroactive polymers, and other emerging smart materials. Sensing and actuation mechanisms. Physics-based, control-oriented modeling of transducer dynamics. Modeling and control of hysteresis. Device and system applications in sensing, actuation, and energy harvesting.

820 Advanced Computer Architecture
Fall, Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 410 and CSE 420 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 820
Instruction set architecture. Pipelining, vector processors, cache memory, high bandwidth memory design, virtual memory, input and output. Benchmarking techniques. New developments related to single CPU systems.

821 Advanced Power Electronics and Applications
Fall. 3(3-0) RB: Power and computer engineering areas.
Power semiconductor devices, circuits, control, and applications. Converter and inverter analysis and design, DSP (Digital Signal Processor) control and implementation. Automotive and utility applications.

823 Power System Stability and Control
Fall of even years. 3(3-0) RB: ECE 826 SA: EE 823
Analysis and simulation of small and large disturbance stability of power systems. Generator, exciter, voltage regulator models. Design of excitation systems and power system stabilizers.

825 Alternating Current Electrical Machines and Drives
Spring of even years. 3(3-0) RB: ECE 320 SA: EE 825
Analysis, modeling and design of synchronous, induction, and switched reluctance machines. Design drives for motion control and power system applications.

831 Analog Circuit Theory
Spring of even years. 3(3-0) SA: EE 831

832 Analog Integrated Circuit Design
Spring of even years. 3(3-0) SA: EE 832

835 Advanced Electromagnetic Fields and Waves I
Fall. 3(3-0) SA: EE 835

836 Advanced Electromagnetic Fields and Waves II
Spring of even years. 3(3-0) RB: ECE 835 SA: EE 836

837 Computational Methods in Electromagnetics
Spring of odd years. 3(3-0) P: ECE 835 R: Open to graduate students in the Department of Electrical and Computer Engineering and open to graduate students in the Department of Mathematics.

848 Evolutionary Computation
Fall of even years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 841 and CSE 440 R: Open to graduate students in the Department of Computer Science and Engineering and open to graduate students in the Department of Electrical and Computer Engineering or approval of department.
Investigation of evolutionary computation from a historical, theoretical and application viewpoint. Readings from the present literature, experiments with provided software on the application of evolutionary computation principles.

849 Digital Image Processing
Spring of even years. 3(3-0) RB: ECE 466
Fundamentals of vision and image formation, various image transforms, linear and nonlinear techniques for image enhancement, image restoration and deconvolution, introduction to wavelet transforms and multi-resolution image processing techniques, morphological image processing, homomorphic filters, image representation and analysis techniques, application to biomedical images.

850 Electrodynamics of Plasmas
Spring of odd years. 3(3-0) Interdepartmental with Astronomy and Astrophysics and Physics. Administered by Electrical and Computer Engineering. RB: ECE 835 or PHY 488 SA: EE 850

851 Linear Systems and Control
Fall. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering. RB: Undergraduate coverage of linear algebra, differential equations and control/systems State models and their stability, controllability, and observability properties. Finding minimal realizations of transfer functions. Design of state and output feedback controllers. Design of state observers. LQ regulator and the Kalman filter. Time-varying systems.
853 **Optimal Control**  
Spring of odd years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering.  
Static optimization. Nonlinear optimal control of discrete and continuous systems, with specialization to the LQ regulator and tracking. Extending the deterministic results to the Kalman filter and the LQG regulator. Dynamic programming and inequality constraints. Convex optimization and LMI’s.

854 **Robust Control**  
Spring of even years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. R: Open to graduate students in the College of Engineering.  

856 **Adaptive Control**  
Fall of even years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering.  

859 **Nonlinear Systems and Control**  
Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. RB: ECE 851 R: Open to students in the College of Engineering. SA: ECE 827  

863 **Analysis of Stochastic Systems**  
Fall. 3(3-0) RB: STT 441 SA: EE 863  
Advanced topics in random variable theory. Stochastic processes and stochastic calculus. Optimal systems for filtering and detection.

864 **Detection and Estimation Theory**  
Spring. 3(3-0) RB: ECE 863 SA: EE 864  
Analysis and implementation of statistical estimation and detection methods used in signal processing, communications, and control applications. Bayesian, Neyman-Pearson, and minimax detection schemes. Bayesian, mean-square-error, and maximum-likelihood estimation methods.

865 **Analog and Digital Communications**  
Fall of odd years. 3(3-0) RB: ECE 457 and ECE 863 SA: EE 865  
Optimum signal detection in noisy channels, matched filters, quadrature sampling of band-pass signals in noise. Coherent and non-coherent binary modulation such as PSK, FSK, DQPSK, M-ary modulation, intersymbol interference, spread spectrum.

866 **Time-Frequency and Wavelet Analysis**  
Spring of even years. 3(3-0) RB: ECE 486  

867 **Information Theory and Coding**  
Fall of odd years. 3(3-0)  
Shannon information measures. Uniqueness theorem and chain rules of the entropy measures. Kullback-Leibler relative-entropy. The I-measure. Asymptotic Equipartition Property (AEP) for various sources. Channel capacity, discrete-memoryless and symmetric channels. The channel coding theorem. Rate-distortion theory. Applications of coding to modern communications and compression methods such as image.

868 **Signal Compression**  
Fall of even years. 3(3-0) RB: Probability theory.  

869 **Wireless Communications and Networking**  
Fall of even years. 3(3-0) RB: ECE 457  
Cellular system design, characterization of wireless channels, signaling and receiver design for mobile radio, multiple access techniques and mobility management.

870 **Introduction to Micro-Electro-Mechanical Systems**  
Fall. 3(3-0) RB: ECE 477 and ECE 474  

871 **Micro-electro-mechanical Systems Fabrication**  
Spring. 3(3-0) P: ECE 870 or ECE 477  
Development of a complete integrated microsystem from inception to final test. Design, fabrication and testing of integrated microsystems. Development of a complete micropipistem system containing sensors, signal processing, and an output interface. Basic MOS device and circuit processes, wafer bonding and micromachining, low power portable devices and diamond MEMS chips.

874 **Physical Electronics**  
Fall. 3(3-0) SA: EE 874  

875 **Electronic Devices**  
Spring. 3(3-0) RB: ECE 874 SA: EE 875  
Operating properties of semiconductor devices including DC, AC, transient and noise models of FET, BJT, metal-semiconductor contact, heterostructure, microwave and photonic devices.

877 **Cleanroom Procedures**  
Fall. 3(3-0) R: Open to graduate students in the College of Engineering.  
Cleanroom procedures and safety. Instrumentation for microfabrication processes and device measurements. Fabrication and testing of devices.

885 **Artificial Neural Networks**  
Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. SA: EE 885  

889 **Master’s Thesis Research**  
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course. SA: EE 899  
Master’s thesis research.

920 **Selected Topics in High Performance Computer Systems**  
Spring of odd years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. R: Open to students in the Computer Science Major or approval of department. SA: CPS 920  
Design of high performance computer systems. Seminar format.

921 **Advanced Topics in Digital Circuits and Systems**  
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. SA: EE 921  
Topics vary each semester.

924 **Power Electronic Systems for Renewable Energy, Transportation, and Utility Applications**  
Spring of even years. 3(3-0) P: ECE 821  

925 **Advanced Topics in Power**  
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 925  
Topics vary each semester.

929 **Advanced Topics in Electromagnetics**  
Fall, Spring. 3 to 4 credits. A student may earn a maximum of 10 credits in all enrollments for this course. SA: EE 929  
Topics vary each semester.
929B Antenna Theory
Fall of odd years. Spring of odd years. 4(4-0) RB: ECE 835 SA: EE 929B

929C Geometrical Theory of Diffraction
Fall of odd years. Spring of odd years. 3(3-0) RB: ECE 835 SA: EE 929C

929D Fast Computational Methods in Electromagnetics and Acoustics
Spring of odd years. 3(3-0) P: ECE 835 R: Open to graduate students in the Department of Electrical and Computer Engineering and open to graduate students in the Department of Physics and Astronomy and open to graduate students in the Department of Mathematics.

931 Advanced Topics in Electronic Devices and Materials
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. SA: EE 931
Topics vary each semester.

931C Properties of Semiconductors
Fall of odd years. Spring of odd years. 3(3-0) RB: ECE 874 SA: EE 931C
Carrier scattering, single particle and collective transport, quantum effects, hot electron effects, electron-photon and electron-phonon interactions.

932 Advanced Topics in Analog Circuits
Spring of odd years. 3(3-0)
Variable topics in advanced circuit analysis.

960c Networked and Embedded Control Systems
Spring of odd years. 3(3-0) P: ECE 851

963 Advanced Topics in Systems
Fall, Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 963
Topics vary each semester.

966 Advanced Topics in Signal Processing
Fall, Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 966
Topics vary each semester.