995 Research Practicum in Educational Administration
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Open only to doctoral students in the College of Education. Approval of department. Supervised research practicum. Design, execution, analysis, presentation, critique, and revision of research projects.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 100 credits in all enrollments for this course. R: Open only to doctoral students in the Department of Educational Administration. Doctoral dissertation research.

ELECTRICAL AND COMPUTER ENGINEERING

Department of Electrical and Computer Engineering
College of Engineering

201 Circuits and Systems I
Fall, Spring, Summer. 3(3-0) P:M: (CSE 131 or concurrently or CSE 231 or concurrently) and (MTHE 230 or concurrently or MTH 254H or concurrently or MTHE 119 or concurrently) SA: ECE 200

202 Circuits and Systems II
Fall, Spring, Summer. 3(3-0) P:M: (ECE 201) and (MTHE 230 or concurrently or MTHE 119 or concurrently or MTH 254H or concurrently) SA: ECE 360

230 Digital Logic Fundamentals
Fall, Spring, Summer. 3(3-0) P:M: (CSE 131 or CSE 231) SA: ECE 330

280 Electrical Engineering Analysis
Fall, Spring. 3(3-0) P:M: (MTHE 234) 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.

291 Circuits and Systems
Fall, Spring. 2(2-0) P:M: (MTHE 235 or concurrently or LBS 119 or concurrently or MTH 255H or concurrently) R: Approval of department. Sinusoidal steady-state response. Laplace transforms. S-Domain circuits analysis. Fourier series.

302 Electronic Circuits
Fall, Spring. 3(3-0) P:M: (ECE 202) R: Open only to students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering. SA: EE 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:M: (ECE 202) and (ECE 302 or concurrently) R: Open only to students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering. SA: EE 303
Electronic test equipment and measurement fundamentals.

305 Electromagnetic Fields and Waves I
Fall, Spring. 4(4-0) P:M: (MTHE 235 or concurrently or LBS 119 or concurrently or MTH 254H or concurrently) and (PHY 184 or PHY 184B or PHY 234B) R: Open only to students in the Department of Electrical and Computer Engineering. SA: EE 305

313 Control Systems
Fall, Spring. 4(4-0) P:M: (ECE 202 or ECE 345) R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering and 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(3-0) P:M: (ECE 302 and ECE 303 and ECE 305) SA: EE 320

331 Microprocessors and Digital Systems
Fall, Spring. 4(3-3) P:M: (CSE 231 and ECE 230) R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 331

345 Electronic Instrumentation and Systems
Fall, Spring, Summer. 3(2-3) P:M: (MTHE 235 or MTH 254H or LBS 119) and (PHY 184 or PHY 184B or PHY 234B) and completion of Tier I writing requirement. R: Open only to students in the Department of Electrical and Computer Engineering with the exception of students in the Department of Electrical and Computer Engineering. SA: EE 345
Electrical and electronic components, circuits and instruments. Circuit laws and applications, frequency response, operational amplifiers, semiconductor devices, digital logic, counting circuits.

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

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

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

407 Electromagnetic Compatibility
Spring. 4(3-3) P:M: (ECE 302 and ECE 305 and ECE 366) R: Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer Engineering major. Electromagnetics for electrical systems. Signals and spectra. Regulations. Radiated and conducted emissions. Conducted and radiated immunity. Mitigation techniques.

410 VLSI Design
Fall, Spring. 4(3-3) P:M: (ECE 302 and ECE 303 and ECE 230) R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering. SA: EE 410
411 Electronic Design Automation
Fall, Spring. 4(3-3) P.M: (CSE 320 or ECE 331) R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering. SA: EE 411

415 Computer Aided Manufacturing
Fall. 3(2-3) P.M: (ECE 313 or ME 451) R: Open only to juniors or seniors in the Manufacturing Engineering major. 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.M: (ECE 303 and ECE 313) R: Open only to juniors or seniors in Electrical Engineering or Computer Engineering.

418 Algorithms of Circuit Design
Fall. 3(3-0) P.M: (ECE 302 and ECE 303 and ECE 366) R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 418

420 Machines and Power Laboratory
Spring. 1(3-0) P.M: (ECE 320 or concurrently or ECE 423 or concurrently) R: Open only to juniors or seniors in the Department of Electrical and Computer 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.M: (ECE 320) R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering. SA: ECE 421

457 Communication Systems
Spring. 3(3-0) P.M: (ECE 302 and ECE 366) R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 457

458 Communication Systems Laboratory
Spring. 1(0-3) P.M: (ECE 303 and ECE 457 or concurrently) SA: EE 458
A projects laboratory in communication systems.

466 Digital Signal Processing and Filter Design
Fall. 3(3-0) P.M: (ECE 366) R: Open only to seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 466

474 Principles of Electronic Devices
Fall, Spring. 3(3-0) P.M: (ECE 302 and ECE 305) SA: EE 474
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.M: (ECE 302 and ECE 303 and ECE 305) R: Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer 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.M: (ECE 474 or concurrently) R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering. SA: ECE 483
Microelectronic processing fundamentals and simulations. Comparison of current microfabrication technologies and their limitations.

480 Senior Design
Fall, Spring. 5(3-6) P.M: (ECE 303 and ECE 313 and ECE 320 and ECE 331 and ECE 366) or (CSE 410 and CSE 420 and CSE 430 and CSE 440) R: Open only to seniors in the Department of Electrical and Computer Engineering. SA: ECE 481, ECE 482, ECE 483
Electrical engineering and computer engineering senior design experience involving contemporary design tools and practices, engineering standards, ethics, cross-functional teaming, oral and written technical communication, 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.

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 only to students in the Department of Electrical and Computer Engineering. SA: EE 491
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. R: Approval of department. SA: EE 801
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.

807 Computer System Performance and Measurement
Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Department of Computer Science and Engineering. RB: (CPS 410 and STT 441) R: Open only to Computer Science or Electrical Engineering majors. SA: EE 807

808 Modelling and Discrete Simulation
Fall, Spring, Summer. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Department of Computer Science and Engineering. RB: (CPS 330 and STT 441) R: Open only to Computer Science or Electrical Engineering majors. SA: EE 808

809 Algorithms and Hardware Implementation
Fall. 3(3-0) Interdepartmental with Computer Science and Engineering. SA: EE 809
Arithmetic, signal processing, and image processing algorithms. Array structures: systolic architecture, data flow structure, neural network architecture. Performance analysis.

813 Advanced VLSI Design
Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. P.M: (ECE 410) SA: EE 813
814 Embedded Wireless RF Transceivers
Fall of even years. 3(3-0)
Transceiver architecture designs. Software components. Real-time 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
Fall. 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.

820 Advanced Computer Architecture
Fall, Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Department of Computer Science and Engineering. RB: (CPS 410 and CPS 420) R: Open only to Computer Science or Electrical Engineering majors. SA: EE 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 of odd years. 3(3-0)
Power semiconductor devices, circuits, control, and applications. Converter and inverter analysis and design, DSP control and implementation. Automotive and utility applications.

822 Parallel Processing Computer Systems
Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Department of Computer Science and Engineering. RB: (CPS 820) R: Open only to Computer Science or Electrical Engineering majors. SA: EE 822 Massively parallel SIMD processors, multiprocessor architectures, interconnection networks, synchronization, and communication. Memory and address space management, process management and scheduling. Parallel compilers, languages, performance evaluation.

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.

824 Power System Operation and Control
Fall of odd years. 3(3-0) RB: (ECE 421 and STT 351) SA: EE 824 Operation planning of power systems including loadflow, unit commitment, production cost methods. On line operation and control including automatic generation control, economic dispatch, security assessment, state estimation.
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.

885 Artificial Neural Networks
Fall. 3(3-0) Interdepartmental with Computer Science and Engineering. SA: EE 885

899 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 Department of Computer Science and Engineering. RB: (CPS 822) R: Open only to Computer Science or Electrical Engineering majors. SA: EE 920
Design of high performance computer systems. Seminar format.

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

921A Testable and Fault-tolerant Digital Systems
Fall of odd years. Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. RB: (ECE 809 and ECE 813) SA: EE 921A

921B Embedded Architectures
Fall of odd years. Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. RB: (ECE 809 and ECE 813) SA: EE 921B

921C Electronic Systems Packaging
Fall of odd years. Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. RB: A basic background in electronics and electromagnetics. VLSI packaging technology, thermal management, electrical design, switching noise, multi-chip packaging, materials, device assembly, RF device packaging, and electrical testing.

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.

925C Advanced Machine Drives
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 825 and ECE 829) SA: EE 925C
Nonlinear drives based on state reconstruction and nonlinear and adaptive control. Sensors, implementation, special computer architectures.

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.

929A Planar Waveguides and Circuits
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 835) SA: EE 929A

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

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.

931A VLSI Technology
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 875) SA: EE 931A
Oxidation, doping techniques, simulation techniques, film deposition and etching, epitaxial growth, lithography, passivation, and packaging.

931B Microdevices and Microstructures
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 875) SA: EE 931B

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.

960 Advanced Topics in Control
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (ECE 827 and ECE 829) SA: EE 960
Topics vary each semester.

960A Adaptive Control
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 827 and ECE 829) SA: EE 960A

960B Nonlinear Control
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 827 and ECE 829) SA: EE 960B

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.

966A Discrete Time Processing of Speech Signals
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 466 and ECE 863 and ECE 864) SA: EE 966A
966B Multidimensional Signal Processing
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 466 and ECE 864) SA: EE 966B
Multidimensional signals and systems concepts. Two-dimensional sampling, windowing, filter design, fast algorithms for convolution and transforms. Sensor array processing. Interpolation.

966C Advanced Topics in Signal Processing
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 466 and ECE 863 and ECE 864) SA: EE 966C
Communication channels, noise models, hypothesis testing of signals by Bayesian minimax, and Neyman-Pearson criteria. Performance evaluation using ROC. Bayesian and maximum likelihood parameter estimation. Kalman-Bucy filtering.

989 Advanced Topics in Plasma
Fall of odd years. Spring of odd years. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. SA: EE 989
Topics vary each semester.

989A Plasma Processing for IC Fabrication
Fall of odd years. Spring of odd years. 3(3-0) RB: (ECE 835 and ECE 850) SA: EE 989A
Process requirements. Plasma reactors. Etching and deposition applications. Broad ion beam processing.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 72 credits in all enrollments for this course. SA: EE 999
Doctoral dissertation research.

ENGINEERING EGR

College of Engineering

101 Preview of Science
Fall. 1 credit. Interdepartmental with Natural Science; Agriculture and Natural Resources; Social Science. Administered by College of Natural Science. R: Approval of college.

124 Internet and Technology
Fall, Spring, Summer. 2(2-0)
The Internet from a user perspective and from a technical perspective. History and social impact of the Internet. Internet tools.

150 Engineers and the Engineering Profession
Spring. 2(2-0) P:M: (MTH 116 or concurrently or MTH 132 or concurrently) or (LBS 118 or concurrently) R: Open only to freshmen or sophomores.

160 Diversity and Engineering
Fall, Spring. 2(2-0) P:M: (MTH 116 or concurrently or MTH 132 or concurrently) R: Open only to freshmen or sophomores in the College of Engineering.

192 Environmental Issues Seminar
Fall, Spring. 1 credit. A student may earn a maximum of 4 credits in all enrollments for this course. Interdepartmental with Natural Science; Agriculture and Natural Resources; Social Science; Communication Arts and Sciences. Administered by College of Natural Science. R: Open only to students in the College of Agriculture and Natural Resources or College of Engineering or College of Natural Science or College of Communication Arts and Sciences or College of Social Science. Approval of college.
Environmental issues and problems explored from a variety of perspectives, including legal, scientific, historical, political, socio-economic, and technical points of view.

210 Independent Study
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Open to students in the College of Engineering, approval of college.
Independent undergraduate research in engineering.

211 Selected Topics
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Open only to freshmen or sophomores.
Experimental course development or special topics appropriate for freshmen and sophomores.

291 Applications in Environmental Studies
Fall. 2(1-2) Interdepartmental with Natural Science; Agriculture and Natural Resources; Communication Arts and Sciences; Social Science. Administered by College of Natural Science. P:M: (NSC 192) R: Open only to students in the Specialization in Environmental Studies.
Community engagement project. Projects vary depending on student's major and area of environmental interest.

300 Technology, Society and Public Policy
Fall. 2(2-0) P:M: Completion of Tier I writing requirement. RB: Two courses in mathematics or engineering or science. SA: EGR 200, MSM 300

393 Engineering Cooperative Education
Fall, Spring, Summer. 1(1-0) A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to students in the College of Engineering.
Pre-professional educational employment experiences in industry and government related to students major. Educational employment assignment approved by College of Engineering.

400 Special Problems in International Engineering
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors or graduate students in the College of Engineering.
Supervised study of selected topics in engineering using laboratories, equipment, and engineering design techniques. Given at various international universities and institutes.

410 System Methodology
Spring. 2(1-3) P:M: (EGR 300 and STT 351) and (ECE 345 or concurrently and ME 222 or concurrently) R: Open only to students in the Applied Engineering Sciences major. SA: SYS 410, MSM 400
System analysis and design. Needs analysis, system identification, graphical models. Team project required.

475 Special Topics in International Engineering
Fall, Spring. 1 to 6 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors or graduate students in the College of Engineering.
Topics selected to supplement regular courses. Given at various international universities and institutes.

490 Independent Study (W)
Fall, Spring. 1 to 4 credits. R: Open only to juniors and seniors in the College of Engineering. Approval of the College of Engineering.
Individualized reading, research, and/or project.

888 Capstone Project in Manufacturing
Fall, Spring, Summer. 3(1-6) Interdepartmental with Marketing and Supply Chain Management. Administered by Department of Marketing and Supply Chain Management. R: Open only to seniors in the Manufacturing Engineering major or to students in the Business Management of Manufacturing major.
Problem solving in manufacturing. Design of processes and processes for manufacturing using a systems approach. Teaming and communication skills are emphasized.