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 ECE

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 (MTH 234 or concurrently or MTH 254H or concurrently or LBS 119 or concurrently) SA: ECE 200

Resistive circuits. Loop and modal analysis. Network theorems, dependent sources. Capacitor and inductor circuits. Transient analysis. Introduction to computer-aided design.

202   Circuits and Systems II
Fall, Spring, Summer. 3(3-0) P:M: (ECE 201) and (MTH 235 or concurrently or LBS 119 or concurrently or MTH 255H or concurrently) SA: ECE 360

Sinusoidal steady-state response. Laplace transforms. S-Domain circuit analysis. Frequency response. Fourier series. Mutual inductance. Power in sinusoidal steady state.

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

Binary information. Switching algebra, combinational logic, minimization. Programmable logic devices. Sequential system fundamentals and state machines. Arithmetic operations and circuits. Memory elements and systems. Design tools. Design problems.

280   Electrical Engineering Analysis
Fall, Spring. 3(3-0) P:M: (MTH 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: (MTH 235 or concurrently or LBS 119 or concurrently or MTH 255H or concurrently) R: Approval of department. SA: ECE 360

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, Summer. 4(4-0) P:M: (MTH 235 or concurrently or LBS 119 or concurrently or MTH 255H 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

Transient and time-harmonic transmission lines. Smith charts. Two-port networks. Maxwell's equations. Force, energy, and power. Plane electromagnetic waves. Guided waves.

313   Control Systems
Fall, Spring. 3(3-0) 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

Power and energy. Magnetics and transformers. Elementary and induction machines. Power semiconductors. Controlled rectifiers and inverters. Power supplies and motor drives.

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

Microcomputers. Microprocessor architecture. Addressing modes. Assembly language programming. Parallel and serial input and output. Interfacing. Interrupts. Peripheral device controllers. Applications, design.

345   Electronic Instrumentation and Systems
Fall, Spring, Summer. 3(2-3) P:M: (MTH 235 or MTH 255H 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 College of 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, semi-conductor 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

Continuous- and discrete-time signal analysis fundamental to modern signal processing and communications technologies. Fourier and spectral analysis of signals. Elementary modulation techniques. Filtering and channel models. The z-transform. Introduction to random processes and noise in discrete time. Application examples.

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

Microwave networks. Scattering parameters. Solutions to Coulomb's law, Gauss' Law and the wave equation. Planar transmission lines. Antennas. Waveguides and cavities. Measurement of the properties of antennas and microwave networks.

407   Electromagnetic Compatibility
Spring. 4(3-3) P:M: (ECE 202 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

Digital integrated circuit design fundamentals. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standards, silicon compilers, foundries. Design layout rules, rule checking. Circuit extraction, simulation, verification. Team-based design.

Electrical and Computer Engineering—ECE

411 Electronic Design Automation
Fall, Spring. 4(3-3) P:M: (CSE 320 or ECE 331) 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 411

Electronic circuit design hierarchy and the role of methodology. Application specific integrated circuits. Hardware description languages. Behavioral and structural circuit modeling. Design algorithms and design tools. Design projects.

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.

State-space models. Analysis and design of control systems using state models. Digital control. Discrete-models of sampled-data systems. Quantization effects and sample-rate selection. System identification. Simulation of nonlinear control systems. Examples of nonlinear phenomena. State of the art of control engineering. Control laboratory.

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

Design of analog electrical circuits, filter functions, ladder synthesis, inductor simulation. Vector Newton-Raphson method. Lossy inductance and capacitance. Statistical tolerance analysis. Optimization by multi-dimensional search. Software algorithms.

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

Synchronous machines. Models and measurements of power components. Symmetrical components. Short-circuit analysis and equipment protection. Load flow. Voltage and frequency control. Operation and planning of power systems.

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

Representation and processing of signals in the presence of noise. System performance. Modulation, detection, and coding of information. System design applications in radar, sonar, radio, television, satellite communications, digital telephony, and wireless systems.

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

Discrete Fourier transforms, sampling theorem, circular convolution, Z-transforms. Design of infinite impulse resistance filters using prototypes and algorithmic methods. Design of finite impulse resistance filters by windowing, frequency sampling.

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 completion of Tier I writing requirement. 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

Queueing network modelling, general analytic techniques, workload characterization, representing specific subsystems, parameterization. Software and hardware monitors, performance measures. Case studies, software packages.

808 Modelling and Discrete Simulation
Fall of even years. 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

Simulation examples, and languages. Mathematical models, petri nets, model validation, random variate generation. Analysis of simulation data. Case studies.

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

Advanced topics in digital integrated circuit design. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standard cells. Design-rule checking. Circuit extraction, simulation, verification. Team-based design.

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
        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.

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.

826   Linear Control Systems
        Fall. 3(3-0) RB: (MTH 314) SA: EE 826
Vector spaces, representation, system description, solution to the state equations, stability, controllability and observability. Adjoints of linear maps. Eigenstructure assignment. Partial and full order observers. Disturbance decoupling.

829   Optimal Multivariable Control
        Spring. 3(3-0) RB: (ECE 826) SA: EE 829
Performance and robustness. Minimum time, minimum energy and regulator. Optimal control and minimum principle. LQG, Nyquist, and H-infinity design methods.

831   Analog Circuit Theory
        Fall of even years. 3(3-0) SA: EE 831
Positive real functions. Filter approximations. Passive and active network synthesis. Nullor network analysis and synthesis. Active filters. Stability. Sensitivity.

832   Analog Integrated Circuit Design
        Fall of odd years. 3(3-0) SA: EE 832
Technology. Device modeling. Circuit simulation. Integrated circuit building blocks. Amplifiers, comparators, converters. Switched-capacitor filters. Analog signal processing circuits.

835   Advanced Electromagnetic Fields and Waves I
        Fall. 3(3-0) SA: EE 835
Electrostatics, magnetostatics, electrodynamics and Maxwell's equations. Potential functions. Eigenfunction expansion. Green's functions. Radiation of EM waves. EM boundary-value problems. TEM waves. Maxwell's equations with magnetic sources.

836   Advanced Electromagnetic Fields and Waves II
        Spring. 3(3-0) RB: (ECE 835) SA: EE 836
Theory of guided transmission system. Microstrip lines, metallic and dielectric waveguides. EM cavities. Excitation and discontinuities of waveguides. Surface wave and radiation modes. Integrated optics. Scattering of EM waves.

841   Fourier Optics
        Spring of odd years. 3(2-3) RB: (ECE 360) and (ECE 435 or ECE 835) SA: EE 841
Scalar diffraction theory. Fourier expansion of optical fields. Spatial linear systems and information processing. Lenses. Optical imaging systems. Holography. Measurements of optical systems.

842   Quantum Electronics
        Fall of even years. 3(3-0) RB: (ECE 835 and ECE 874) SA: EE 842
Quantum and electromagnetic theory of lasers. Optical resonators. Laser oscillation and amplification. Characterization of lasers. Specific laser examples.

850   Electrodynamics of Plasmas
        Spring of odd years. 3(3-0) Interdepartmental with Astronomy and Astrophysics; Physics. RB: (ECE 835 or PHY 488) SA: EE 850
Plasma kinetic and macroscopic plasma transport theory. Electromagnetic wave propagation and charged particle diffusion processes in plasma. Electromagnetic energy absorption via elastic and inelastic collisions. Dc, rf, and microwave discharges.

859   Nonlinear Control
        Spring. 3(3-0) Interdepartmental with Mechanical Engineering. RB: (ECE 826 and ME 857) SA: ECE 827
Second-order systems. Fundamental properties of solutions. Lyapunov stability. Input-output stability. Passivity. Absolute stability. Linearization. Integral control. Feedback linearization. Sliding mode control. Lyapunov redesign. Passivity-based control. Recursive methods. Applications to electrical and mechanical systems.

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 design in noisy channels, matched filters, quadrature sampling of band-pass signals in noise. Coherent and non-coherent binary modulation such as PSK, FSK, DPSK, M-ary modulation, intersymbol interference, spread spectrum.

867   Information Theory and Coding
        Spring. 3(3-0) P:M: (ECE 863)
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, video, speech and watermarking.

870   Introduction to Micro-Electro-Mechanical Systems
        Fall. 3(3-0) RB: (ECE 477 and ECE 474)
Micro-electro-mechanical systems (MEMS). Fundamentals of micromachining and microfabrication techniques. Design and analysis of devices and systems in mechanical, electrical, fluidic, and thermal energy and signal domains. Sensing and transduction mechanisms, including capacitive and piezoresistive techniques. Design and analysis of miniature sensors and actuators. Examples of existing devices and their applications.

Electrical and Computer Engineering—ECE

**871   Micro-electro-mechanical Systems
        Fabrication**
        Spring. 3(3-0) P:M: (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 multichip microsystem containing sen-
sors, 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
Applications of quantum mechanics and statistical
mechanics in solids. Band theory of semiconductors.
Electrical transport phenomena. Pn junctions.

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, het-
erostructure, microwave and photonic devices.

885   Artificial Neural Networks
        Fall. 3(3-0) Interdepartmental with Com-
        puter Science and Engineering. SA: EE 885
Overview of neuro-engineering technology. Basic
neural network architectures. Feedforward and
feedback networks. Temporal modeling. Supervised
and unsupervised learning. Implementation. Basic
applications to pattern recognition.

899   Master's Thesis Research
        Fall, Spring, Summer. 1 to 8 credits. A stu-
        dent 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 enroll-
        ments 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, Spring. 3(3-0) A student may earn a
        maximum of 6 credits in all enrollments for
        this course. Interdepartmental with Com-
        puter 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 Sci-
        ence and Engineering. RB: (ECE 809 and
        ECE 813) SA: EE 921A
Reliability evaluation. Fault models and test pattern
generation. Design for testability. Fault-tolerant
design techniques, self-checking circuits and sys-
tems, system diagnosis and reconfiguration.

921B   Embedded Architectures
        Fall of odd years. Spring of odd years. 3(3-
        0) Interdepartmental with Computer Sci-
        ence and Engineering. RB: (ECE 809 and
        ECE 813) SA: EE 921B
Embedded computers and architectures for real-
time computation and/or robust control. ASICs. Bit-
slice architectures. Systolic arrays. Neural networks.
Genetic algorithms. Implementation technologies
and design issues.

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

925   Advanced Topics in Power
        Spring. 3(3-0) A student may earn a maxi-
        mum 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, implemen-
tation, 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 enroll-
        ments 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
Planar open-boundary waveguides and circuits.
Surface and microstrip waveguides. Propagation-
mode spectrum. Spectral analysis of layered media.
Sommerfeld analysis. Integral-operator description
of open waveguides and planar circuits.

929B   Antenna Theory
        Fall of odd years. Spring of odd years. 4(4-
        0) RB: (ECE 835) SA: EE 929B
Antennas and EM scattering. Radiation by currents
and surface fields. Equivalence principle. Receiving
antennas. Arrays and synthesis. Integral equations.
Current and impedance of wire antennas. Slot,
aperture and reflector antennas. Singularity expan-
sion method.

929C   Geometrical Theory of Diffraction
        Fall of odd years. Spring of odd years. 3(3-
        0) RB: (ECE 835) SA: EE 929C
Fourier expansion and asymptotic evaluation of two-
dimensional electromagnetic fields. Scattering from
half-planes, wedges and cylinders. Geometrical
optics and ray-tracing. Reflection and transmission
matrices. Geometrical diffraction theory.

**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 enroll-
        ments 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 tech-
niques, 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
Technology, modeling and simulation of submicron
solid state devices. Microsensors and micromachin-
ing. Diamond and superconducting devices. Vac-
uum microelectronic structures.

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
Model reference adaptive control in continuous and
discrete time. Lyapunov and hyperstability ap-
proaches, adaptive observers, self-tuning regulators,
design using pole-zero assignments. Minimum
variance and LQG control.

960B   Nonlinear Control
        Fall of odd years. Spring of odd years. 3(3-
        0) RB: (ECE 827 and ECE 829) SA: EE
        960B
Relay control, stabilizing controllers. Design via
variable structure, high gain, geometric, and
Lyapunov-based methods. Feedback linearization
and tracking controls.

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
Digital speech models. Short term temporal process-
ing. Linear predictive and spectral analysis. Speech
coding and synthesis, recognition, enhancement.

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 Statistical 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.

Overview of natural sciences. Transitional problems. Communications and computer skills. Problem-solving skills. Diversity and ethics problems in science. Science and society.

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.

Overview of the engineering profession. Historical background. Engineering specialties. Engineers at work. Professionalism and ethics. Communication skills. Future trends and challenges.

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.

Diversity and engineering. Transitional problems. Career options. Communication skills.

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.

290   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 only to students in the College of Engineering, approval of college.

Independent undergraduate research in engineering.

291   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.

292   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

Defining, describing and analyzing technology. Impact of technology on society. Public policy and technology. Short history of technology. Development and use of assessment tools to measure impact and consequences of technology.

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 student's 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, 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.

Topics selected to supplement regular courses. Given at various international universities and institutes.

490   Independent Study (W)
Fall, Spring, Summer. 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 products and processes for manufacturing using a systems approach. Teaming and communication skills are emphasized.

ENGLISH   ENG

Department of English
College of Arts and Letters

097   Oral Skills for Foreign Teaching Assistants
Fall, Spring. 0(5-0) R: Approval of English Language Center.

Practice in English skills for classroom instruction. Pronunciation. Presentations and handling questions. Managing student interactions and classroom situations.

101   Cross-Cultural Literature
Fall, Spring, Summer. 4(4-0)

Fiction, drama, or poetry of major authors, written in or translated into English, reflecting a broad range of cultures.