973B. *College Student Affairs Administration II*

Winter of even-numbered years. 3(3-0) Doctoral students in College and University Administration; EAD 973A.

Planning, organization, financing, research, evaluation and administration of student organizations and activities. Emphasis on student unions and on- and off-campus housing and services.

973C. *College Student Affairs Administration III*

Spring of even-numbered years. 3(3-0) Doctoral students in College and University Administration; EAD 973B.

Student rights and responsibilities; academic freedom; regulation of student conduct; systems of governance and judicial processes. Legal basis for student personnel programs and administration.

976A. *Doctoral Internship in College and University Administration*

Fall, Winter, Spring, Summer. 3(0-9) May reenroll for a maximum of 12 credits. Doctoral students in College and University Administration, approval of instructor.

Students intern in on- and off-campus offices and agencies as observers of and participants in the administration of programs particular to their major field of study.

978A. *Independent Research in Higher Education Administration*

Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 6 credits. Doctoral students in College and University Administration.

Supervised and guided in-depth readings in literature and research specific to higher education administration which lead to the development of materials such as position papers, articles for publication, and grant and dissertation proposals.

982. *Seminars in Administration and Curriculum*

Fall, Winter, Spring, Summer. 1 to 9 credits. May reenroll for a maximum of 15 credits. Approval of department.

Seminars in the various fields of emphasis.

983. *Readings and Independent Study in Educational Administration*

Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.

Study on an individual or group basis in the various fields of emphasis.

984. *Laboratory and Field Experience in Educational Administration*

Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.

Supervised advanced graduate practicums, observation, internships, and externships in the various areas of emphasis.

999. *Doctoral Dissertation Research*

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

ELECTRICAL ENGINEERING

College of Engineering

Electrical Engineering — E E

300. *Electric Circuits I*

Fall, Winter. 4(4-0) MTH 113.

Current voltage and power. DC and transient circuit analysis. Forced response. Sinusoids and the phasor concept. Bridges.

301. *Electric Circuits II*

Winter, Spring. 3(3-0) E E 300, MTH 214.

Sinusoidal steady state response. Average power and rms concepts, complex frequency response. Two-port networks. Transfer functions.

302. *Basic Electronic Circuits*

Fall, Spring. 4(4-0) E E 301, MTH 215.

Volt-ampere characteristics of diodes and transistors. Voltage, current and power amplification. Stability, transient and high-frequency effects. Feedback, oscillators and operational amplifiers.

303. *Electronics Laboratory I*

Winter, Spring. 1(0-3) E E 300; E E 301 concurrently.

Electronic test equipment and measurement fundamentals. Experimental verification of topics covered in E E 300 and E E 301. Computer-aided circuit analysis and design.

304. *Electronics Laboratory II*

Fall. 1(0-3) E E 302.

Experimental verification of topics covered in E E 302. Single-stage and multi-stage transistor amplifier design and analysis. Applications of linear integrated circuits. Computer-aided circuit design.

305. *Electromagnetic Fields and Waves I*

Fall, Winter. 3(3-0) MTH 310, PHY 288.

Vector analysis, Electrostatic fields; EM sources, scalar potential, Poisson's and Laplace's equations, dieletric media, capacitance, and energy storage. Boundary value problems for electronstatic fields.

306. *Electromagnetic Fields and Waves II*

Winter, Spring. 3(3-0) E E 305.

Electromagnetic fields; EM sources, vector potential, magnetic media, inductance; energy storage time varying fields, and Maxwell's equations; potential theory and boundary value problems.

307. *Electromagnetic Fields and Waves III*

Spring, Summer. 3(3-0) E E 306.

Application of Maxwell's equations; radiation, propagation, reflection, and power flow of plane EM waves; EM boundary value problems. Transmission line theory: transient and steady state waves, standing and traveling waves, reflections and standing-wave-ratio.

308. *Fields and Waves Laboratory*

Fall, Spring. 1(0-3) E E 307 or concurrently.

Experimental investigation of: charged particle motion in EM fields, dieletric and magnetic properties and materials, probing of currents and charges, and propagation of transient and steady-state waves. Digital computer solutions for EM field and wave problems.

311. *Machine Organization and Assembly Language Programming*

Fall, Winter, Spring. 4(3-3) MTH 214; CPS 252 or CPS 301 or CPS 304. Interdepartmental with and administered by the Department of Computer Science.

Machine structure, registers and operations. Subprogram linkage. Discrimination of translator, loader and execution tasks. Programming in assembly language.

315. *Discrete-Time Systems*

(SYS 311.) Fall, Winter. 3(3-0) MTH 215.

Discrete-time system modeling, discrete-time signals, difference equations, convolution summations, z-transform, transfer functions, stability analysis, digital filters.

320. *Electromechanical Energy Conversion*

Fall, Spring. 3(3-0) E E 301, E E 306.

Review of electromagnetics, three phase power, transformers, electromechanical energy conversion, basic concepts of rotating machines, alternating current machines.

330. *Digital Logic Fundamentals*

(E E 230.) Fall, Winter, Spring, Summer. 4(4-0) CPS 252. Interdepartmental with the Department of Computer Science.

Boolean algebra, combinational logic and minimization, sequential system fundamentals and components; arithmetic operations and devices; memory devices and ensembles; digital integrated circuits; practical engineering design problems.

345. *Introduction to Electronic Instrumentation Systems*

Fall, Winter. 4(3-3) PHY 288.

Basic electronic concepts; passive and active components; operational amplifiers; switching devices, equivalent circuits; transducers; signal conditioning; recording; data management; basic elements of control.

355. *Deterministic Communication Systems*

Fall, Spring. 3(3-0) E E 301, MTH 214.

Communication systems. Representation of signals in time and frequency domain. Processing of signals by linear, simple nonlinear and time-variant systems. Linear and nonlinear, analog and digital modulation and demodulation; for example, AM, FM, PCM.

410. *Digital Circuit Design I*

Fall, Winter, Spring. 4(3-3) E E 330, E E 302.

MOS and BJT transistor models; SPICE models and simulation; logic family characteristics; latches, flip-flops; timers; memory circuits; timing diagrams; gate arrays; standard cells; microprocessors; PLAs.

411. *Digital Design Automation*

Winter, Spring. 4(3-3) E E 410.

Computer-aided engineering of digital circuits; application-specific integrated circuits; design hierarchy; schematic capture; functional specifications; behavioral models; hardware description languages; design verification; testability; sequential circuit design.

412. *Computer Communications*

Fall, Winter, Spring. 3(3-0) CPS 311; STT 351 or STT 441. Interdepartmental with and administered by the Department of Computer Science.

Computer networks; analysis by queueing theory; network design algorithms, routing and flow.

413. *Analysis of Control Systems*
(SYS 413.) Fall. 4(4-0) E E 301, E E 355.
Control system characteristics, performance criteria, transient and steady-state responses, error analysis, stability, root locus and frequency response techniques. Controller design using root locus and frequency response methods.

414. *Control Systems Laboratory*
Winter, Spring. 1(0-3) CPS 311, E E 304, E E 413.
Experimental investigations of feedback systems. Study of solid state controllers. Properties and applications of phase lock loops. Introduction to digital control.

415. *Digital Control Systems*
Winter. 3(3-0) CPS 311, E E 315, E E 413.
Organization of digital control systems, classical and modern techniques for the design of digital control systems. Hardware and software considerations with emphasis on microprocessor implementation.

416. *Computers in Robotics*
Spring. 3(2-3) E E 415.
Topics include overview of robots, sensors, homogeneous transforms, kinematics, trajectory planning, control and introduction to vision.

417. *State Models, Analysis, and Simulation*
(SYS 412.) Spring. 3(3-0) E E 315, MTH 310, MTH 334.
Vector-matrix state-space models of dynamic systems, exponential matrix, transform solutions, convolution, stability, controllability, observability, simulation, computational techniques, extensions to nonlinear systems.

418. *Introduction to Computer-Aided Circuit Design*
Fall. 3(3-0) CPS 301, E E 302.
Introduces the techniques used for automatic formulation, analysis and optimization of linear and nonlinear electronic circuits. Students will write a modest but useful analysis program package.

419. *Physical Phenomena and Electronic Instrumentation I*
Winter. 4(3-3) PHY 289, PHY 298 or approval of department, MTH 215. Interdepartmental with and administered by Physics.
Concepts of electronics relative to uses in investigations of physical phenomena and their subsequent applications to provide reliable instrumentation. Nuclear radiation detectors, photometers and magnetometers are examples of specific topics covered.

421. *Power System Analysis*
Spring. 3(3-0) E E 320 or concurrently.
Model of power system components; analysis and planning techniques including load flow, short circuit, transient stability; voltage and frequency control; economic operation of power systems.

422. *Power Electronics*
Winter. 3(3-0) E E 302, E E 320.
Thyristor characteristics, commutation, AC voltage controllers, single-phase and three-phase rectifier and inverter circuits, DC-to-DC converters, cycloconverters, AC and DC motor drives.

423. *Electrical Machines Laboratory*
Spring. 1(0-3) E E 320.
Transformers, torque, power and speed characteristics of induction, synchronous and dc machines, steady state and transient operation of machines, machine control.

424. *Computer Architecture I*
Fall, Winter, Spring. 4(3-3) CPS 311, E E 330. Interdepartmental with and administered by the Department of Computer Science.
Computer organization; control unit implementation; input-output, interrupt, and interface design; digital system simulation.

425. *Computer Architecture II*
Winter, Spring, Summer. 4(2-6) CPS 424. Interdepartmental with and administered by the Department of Computer Science.
Microprogrammed control; pipelining; multiprocessing and parallel processing; fault tolerant computing. Implementation of a digital system combining simulation and hardware.

431. *Computer Interfacing*
Fall, Winter, Spring. 4(3-3) CPS 311, E E 410.
Case study of a small computer system; I/O controller design; bus interface requirements, interrupt structure, and data transfer. Digital system design.

435. *Microwave Circuits and Systems*
Fall. 3(3-0) E E 307.
Waves guided by open and closed-boundary systems. Normal modes of microstrip, metallic and dielectric waveguides. Microwave cavities, devices, and circuit theory. S-parameter description of microwave devices. System applications.

436. *Radiation and Reception of Electromagnetic Waves*
Winter. 3(3-0) E E 307.
Radiation, propagation, scattering and reception of electromagnetic waves; circuit and radiation characteristics of wire and microwave and antennas; radiation fields, self and mutual impedances of antennas and arrays; microwave aperture antennas.

438. *Transmission and Radiation Laboratory*
Winter. 1(0-3) E E 435; E E 436 concurrently.
Microwave transmission and radiation laboratory. Measurement of frequency, wavelength, standing waves, impedance, and power. Experiments on transmission lines, waveguides, cavity resonators, microwave circuits, and circuit and radiation properties of antennas.

456. *Applied Probability in Communication Theory*
Fall, Winter. 3(3-0) E E 355.
Probability theory applied to communications. Representation of random signals as stochastic processes. Autocorrelation and spectral density. Noise in components and systems, performance of analog linear and nonlinear systems with noise.

457. *Statistical Communication Systems*
Spring. 3(3-0) E E 456; E E 467 concurrently.
Representation, processing and filtering of random signals. Performance of digital systems with noise. Optimal digital communications systems. Signal detection, information concepts, coding. Communication systems such as radar, television, PCM, and telephony.

466. *Digital Filter Design*
Winter. 3(3-0) E E 355, E E 456.
Design of digital filter algorithms and their implementation; software and hardware considerations. Applications and application driven design.

467. *Communications Laboratory*
Spring. 1(0-3) E E 456; E E 457 concurrently.
Experimental investigations on communication theory and information transmission topics from E E 455, E E 456, and E E 457.

474. *Physical Principles of Electronic Devices*
Fall. 4(4-0) E E 302; E E 305.
Energy levels in atoms and crystals; density of states; Fermi-Dirac and Maxwell-Boltzmann statistics; transport properties of bulk materials; metal-semiconductor contacts; the p-n junction and BJT.

475. *Electronic Devices and Circuits*
Winter. 3(3-0) E E 474.
Fabrication technology; models and characteristics of BJT's, JFET's, and MOS devices; application to linear and digital circuits.

476. *Applications of Electronic Devices*
Spring. 3(3-0) E E 474.
Power devices and applications; transistors, diacs, triacs, and SCR's; high frequency devices and applications; transitors; impatt, Gunn and vacuum devices; photo-devices; solar cells and LED's.

477. *Electro-optic Devices*
Spring of odd-numbered years. 3(3-0) E E 306.
Atomic origin and the operational characteristics of light sources and detectors. Basic design considerations for gas and solid state lasers. Methods of optical detection, applications.

478. *Integrated Circuit Fabrication Laboratory*
Winter, Spring, Summer. 2(1-3) E E 474.
Integrated circuit design and fabrication. Laboratory fabrication of diffused resistors, diodes, capacitors, and simple MOS or bipolar integrated circuits. Yields, testing, and economic considerations.

480. *Integrated Circuits: Operational Amplifiers*
Fall, Winter. 3(3-0) E E 302.
Integrated circuits: design principles and fabrication. Differential-amplifier stage signal characteristics. Properties and models of operational amplifiers. Applications: signal conditioners, signal processors, signal generators, and special-purpose circuits.

495. *Independent Study*
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 3 credits in E E 495 and SYS 495 combined. Approval of department.
Independent study of a topic in electrical engineering of particular interest to the student.

499. *Undergraduate Research*
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 6 credits. Approval of department.
Independent undergraduate research in contemporary areas of electrical engineering such as: alternative energy, monitoring and control, bioengineering, power systems, integrated electronics, electromagnetic systems.

801. Special Problems
Fall, Winter, Spring, Summer. 1 to 4 credits. Approval of department.
Investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

809. Computer Arithmetic Algorithm Design
Fall. 4(4-0) E E 431 or CPS 424. Interdepartmental with the Department of Computer Science.
Number systems; fast two-operand and multioperand addition/subtraction; standard, recoded and cellular array multipliers; high-performance dividers; floating-point arithmetic; error control; pipelining.

812. Computer Networks
Spring. 3(3-0) CPS 412, CPS 413, CPS 424. Interdepartmental with and administered by the Department of Computer Science.
Data communication, baseband and broadband local area networks, logical link control, internet protocol, transport protocol, naming and addressing, interprocess communication, reliable broadcast protocol, distributed processing.

813. Logic Design Methodologies
Spring. 3(3-0) CPS 424 or E E 431. Interdepartmental with the Department of Computer Science.
Modeling and simulation of logic circuits; hardware description languages; design methodologies for logic arrays and bit-slice processors; fault tolerance, testability, computer aided design of logic circuits; automated routing algorithms.

815. Advanced Computer Architecture
Fall, Winter. 3(3-0) CPS 413, CPS 424. Interdepartmental with and administered by the Department of Computer Science.
Classification of computer systems, memory organizations, cache memory, lookahead processor, stack processor, pipeline processor, vector processing, associative processor, super computer architectures, parallel processing, performance issues, case studies.

816. Fault-Tolerant Computing
Winter. 3(3-0) E E 813. Interdepartmental with the Department of Computer Science.
Reliability evaluation; fault models and test pattern generation; design for testability; fault-tolerant design techniques; self-checking circuits and systems; system diagnosis and reconfiguration; case studies.

818. Introduction to Robotics
Spring. 3(3-0) E E 415 or M E 458 or approval of department. Interdepartmental with the Department of Computer Science.
Robot configuration and geometry. Robot drive systems, kinematics, controller design, sensors, sensor-based robots. Economic, political and social implications. Industrial application.

820. Electric Power Transmission System
Spring of odd-numbered years. 4(4-0) E E 421 or approval of instructor.
Symmetrical components, calculation of short circuit currents for symmetrical and unsymmetrical faults; methods and devices used in protection; pilot wire and carrier systems, circuit interruption, grounding.

823. Power System Stability and Control
Fall of even-numbered years. 3(3-0) E E 826.
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-numbered years. 3(3-0) E E 421, E E 413, E E 456 or STT 441.
Operation planning of power systems including load flow, unit commitment, and production cost methods; on line operation and control including automatic generation control, economic dispatch, security assessment, and state estimations.

825. Alternating Current Electrical Machines
Spring of even-numbered years. 3(3-0) MTH 424; E E 320 or approval of instructor.
Analysis, modeling and design aspects of synchronous, induction, and switched reluctance machines for use in power systems stability and control, and in motion control.

826. Advanced Linear Systems Analysis
(SYS 826.) Fall. 4(4-0) MTH 310, MTH 334, approval of instructor.
Analysis of linear continuous time and discrete time systems for both time invariant and time varying models; state space and transfer function models; transition matrices; controllability; observability; minimal realizations; stability.

827. Nonlinear Systems Analysis
(SYS 827.) Spring. 4(4-0) E E 826, MTH 424.
Existence, uniqueness and stability in nonlinear systems; autonomous systems and the phase space; linearization, perturbation, describing functions and harmonic balance procedures; numerical solutions.

829. Linear Multivariable Control Systems
(SYS 829.) Winter. 4(4-0) E E 826, STT 441, E E 413.
Linear continuous time and discrete time multivariable control systems; state and output feedback; observers; eigenstructure placement; asymptotic tracking; optimal linear control; stochastic processes; Kalman filter; LQG optimal control.

831. Active Network Synthesis
Winter. 3(3-0) Approval of department.
S-domain network synthesis. Root-locus design techniques for practical analog signal processors, including sensitivity and stability considerations. Passive network synthesis and functional properties of operational amplifiers.

832. Switched Capacitor Circuits
Spring of odd-numbered years. 3(3-0) E E 475.
Switched capacitor analog circuit analysis and design. Analog sampled data concepts; implementation of signal processing operations; switched capacitor filters; nonideal effects; linear and nonlinear applications.

835. Electromagnetic Theory
Fall. 3(3-0) Approval of department.
Electrostatics, magnetostatics, electrodynamics and Maxwell's equations. Green's function and eigenfunction expansion techniques. Conservation of EM energy and momentum. Radiation of EM waves: Lorentz potentials, Helmholtz integrals, retarded potentials, general EM field.

836. Electromagnetic Waves I
Winter. 3(3-0) E E 835.
EM description of circuits. EM boundary-value problems. Hertzian potentials. Field equivalence theorems. Green's functions. TEM waves: propagation in curvilinear coordinates, transmission and scattering coefficients. Transmission lines: variational methods, microstrip.

837. Electromagnetic Waves II
Spring. 3(3-0) E E 836.
Guided transmission systems. Modes of metallic and open-boundary dielectric waveguides and cavities. Mode orthogonality. Excitation and coupling. Scattering by waveguide discontinuities. Radiation modes. Fiber and integrated optics.

841. Fourier Optics
Spring of even-numbered years. 3(3-0) E E 455 or E E 880, E E 307 or E E 835.
Electromagnetic (Fourier) optics and optical information processing. Spatial linear systems, EM optics and scalar diffraction; lenses; optical imaging systems; optical information processing; holography.

845. Detection and Estimation Theory
Spring of odd-numbered years. 3(3-0) E E 863.
Classical detection theory, hypothesis testing, decision criteria, multiple hypotheses, colored noise, detection of signals with unknown parameters, Bayes estimates, MAP, ML, LMSE, Wiener and Kalman filters, nonlinear estimation, application to communications and radar systems.

846. Information Theory and Coding
Spring of even-numbered years. 3(3-0) E E 863 or approval of instructor.
Discrete and continuous channels. Channel capacity. Shannon's source coding and channel coding theorems. Rate distortion theory. Linear codes, Hamming, BCH, Cyclic codes. Convolutional codes. Viterbi algorithm, sequential decoding.

847. Communication Engineering
Fall. 4(4-0) E E 457.
Communications in probabilistic channels. Measures in system performance. Channel models. Optimal reception of analog and digital signals. Coding for various channel models. Detection of targets. Signal solution.

848. Communication Theory
Spring. 3(3-0) E E 863.
Hypothesis testing, decision theory and parameter estimation in communications and signal processing. Optimal filtering techniques. Communication in non-white noise. Communication in non-Gaussian noise. Quantum detection theory.

849. Microwave Electronics
Spring of odd-numbered years. 3(3-0) E E 835, E E 875.
Microwave gaseous, solid-state and vacuum devices, active microwave integrated circuits and systems, waves in solid-state plasmas and their applications, parametric amplifiers. Design of microwave amplifiers, oscillators and communication systems.

850. Electrodynamics of Plasmas I
Fall. 3(3-0) E E 835 or PHY 448; E E 874. Interdepartmental with the Department of Physics and Astronomy.
Boltzmann equation; moment equations; two-fluid theory of plasma, waves in cold, warm and anisotropic infinite plasma; waves in bounded plasma structures, energy flow in anisotropic plasmas.

857. *Microprocessor-based System Design*
Spring. 4(2-6) E E 431 or CPS 424.
Microprocessor-based system design methodology; performance measures; single-chip computer organization alternatives; local networks of processors; applications in signal processing control and instrumentation.

863. *Analysis of Stochastic Systems*
(SYS 863.) Winter. 3(3-0) E E 826, STT 441, MTH 424.
Analysis and modeling of stochastic signals and systems. Topics include stochastic models, description of processes, stationarity, ergodicity, correlation and power spectrum, linear stochastic systems, harmonic analysis, Markov processes, Poisson processes.

871. *Integrated Circuit Engineering*
Winter. 3(3-0) E E 474.
Fabrication and design of integrated circuits. Physics and chemistry of processing. Comparison of current bipolar and MOS technologies, and their limitations. VLSI design methodology and layout examples.

874. *Physical Electronics*
Fall. 4(4-0) Approval of department.
Application of quantum mechanics in solids, band theory of semi-conductors, electrical transport phenomena, induced current concept, charged particle dynamics, electron optics.

875. *High Speed Solid-State Devices*
Winter. 3(3-0) E E 474.
Formulation of operating properties and appropriate models of devices formed with semiconductors and solid state materials. Emphasis is on performance limitations of high speed integrated circuit unipolar and bipolar devices.

876. *Semiconductor Power Devices*
Spring of even-numbered years. 3(3-0) E E 474.
Formulation of operating properties and appropriate models of devices formed with semiconductors and solid state materials. Performance limitations of semiconductor power devices due to voltage, temperature and power considerations.

880. *Digital Signal Processing*
Winter. 3(3-0) E E 456 or STT 441.
Discrete time signals and systems, random discrete time signals. Basic principles of estimation theory, spectral estimation. Digital filter design techniques.

899. *Master's Thesis Research*
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

911. *General Automata Theory I*
Fall of odd-numbered years. 3(3-0) CPS 423 or E E 827 or approval of department. Interdepartmental with and administered by the Department of Computer Science.
Characterization of machines and programs as automata; mathematical decomposition of finite automata.

920. *Advanced Topics on Power*
Winter. 3(3-0) E E 823 or E E 824.
Current research topics in power system planning, operation and control. Topics may include AC/DC systems, computational methods for balanced and unbalanced systems, stability, and security.

921. *Multiprocessors and Parallel Processing*
Fall. 3(3-0) CPS 812, CPS 815. Interdepartmental with and administered by the Department of Computer Science.
Massively parallel processor, parallel memory, interconnection network, tightly and loosely complied multiprocessors, message-passing model, shared-memory model, operating systems, performance, parallel languages and algorithms.

922. *Advanced Computer Systems*
Winter. 3(3-0) CPS 921, E E 813. Interdepartmental with and administered by the Department of Computer Science.
VLSI and WSI architectures, mapping algorithms to architectures, functional programming, dataflow computer, concurrent symbolic processing and logical programming, computer architecture for artificial intelliegence, recent advances in computer systems.

925. *Control of Electrical Drives*
Fall of even-numbered years. 3(3-0) E E 413, E E 422, E E 825.
Current and voltage source inverter, converter and cycloconverter circuits. Pulse width modulation techniques. Models of electrical machines used in industrial drives, derivation of control algorithms. Microprocessor based control systems.

926. *Antenna Theory I*
Winter of even-numbered years. 3(3-0) E E 835.
Wire antennas as radiating, receiving and scattering elements; analytical and numerical integral equation methods; coupled antennas and arrays; transient phenomena.

927. *Antenna Theory II*
Spring of even-numbered years. 3(3-0) E E 926.
Radiation by equivalent aperture fields; aperture antennas, slot antennas, horn and reflector antennas, frequency independent antennas; pattern theory; scattering from various objects.

929. *Advanced Topics in Electromagnetics*
Winter. 2 to 4 credits. May reenroll for a maximum of 4 credits. E E 835 and approval of department.
Topics will be drawn from contemporary research areas such as transient electromagnetics (SEM solutions), open-boundary waveguides, solid-state lasers, and microwave plasmas.

931. *Electronic Properties of Semiconductors*
Winter of odd-numbered years. 3(3-0) E E 874.
Advanced treatment of phenomena basic to semiconductor materials and devices. Electronic transport, high field effects, recombination theory, electro-optical phenomena, experimental characterization techniques.

932. *Topics in Solid State Device Research*
Spring of odd-numbered years. 3(3-0) E E 874.
Relationship of solid state theory and material properties to device performance. Topics selected from current device research areas and vary with year. Examples are photovoltaic, amorphous semiconductor, and piezoelectric devices.

960. *Nonlinear Control*
Fall of even-numbered years. 3(3-0) E E 827, M E 458 or E E 413. Interdepartmental with and administered by the Department of Mechanical Engineering.
Input-output stability of feedback systems; describing function methods; relay control; stabilizing controllers; design techniques selected from variable structure, high-gain, geometric, Lyapunov-based, vibration, feedback linearization and tracking controls.

961. *Optimal Control Theory*
(SYS 961.) Fall of odd-numbered years. 3(3-0) E E 829, MTH 424.
Optimal control, performance measures, principle of optimality, dynamic programming, Hamilton-Jacobi-Bellman equation, variational approach, constrained extrema, Pontryagin principle, necessary conditions, solution techniques, singular cases.

963. *Dynamic System Identification*
(SYS 963.) Winter of odd-numbered years. 3(3-0) E E 863.
Review of stochastic system modeling; identifiability; canonical forms; spectral factorization; least squares and maximum likelihood identification methods and their properties, consistent estimators; closed-loop system identification, recursive algorithms; experiment design.

964. *Large Scale Dynamic Systems*
(SYS 964.) Spring of even-numbered years. 3(3-0) E E 827, E E 829.
Topics will be drawn from: model reduction and aggregation; stability of interconnected systems; multiple time scale decomposition; decentralized control; hierarchical control.

965. *Adaptive Control*
(SYS 965.) Spring of odd-numbered years. 3(3-0) E E 827, E E 829, E E 963.
Model reference adaptive control in continous time and discrete time; Lyapunov and hyperstability approaches; adaptive observers; self tuning regulators; design using pole-zero assignments, minimum variance control and LQG control.

989. *Electrodynamics of Plasmas II*
Winter of odd-numbered years. 3(3-0) E E 850. Interdepartmental with the Department of Physics and Astronomy.
One fluid plasma model, magnetohydrodynamics, Maxwell's stress tensor, low frequency waves, transport phenomena, Landau damping, collision and rate coefficients. Diffusions in a magnetic field; investigation of dc, rf and microwave discharges.

999. *Doctoral Dissertation Research*
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Systems Science SYS

410. *Systems Methodology*
Winter, Spring. 3(2-3) C E 370, CPS 115 or CPS 112.
Systems analysis and design. Needs analysis. Assignment of input, state and output variables. Graphical and programmable models of systems and components. Completion of team project including verbal briefings and written final report.

442. Systems Concepts for Biologists
Winter. 3(3-0) Approval of department.
Basic concepts of systems science important to formal analysis and control of biological communities, with emphasis on modeling and on analysis of behavior through numerical solutions.

810. Introduction to Linear System Theory
Fall. 3(3-0)
A first course in system theory for students from a range of disciplines. Mathematical representation of system variables, transform and state space method of analysis, introduction to control theory, applications to physical, economic and social systems.

811. System Methodology and Simulation
Winter. 3(3-0) SYS 810, STT 441.
Problem definition, design of abstract models for system design and control, simulation of systems described by differential and difference equations, generation of random variables, simulation of discrete object stochastic systems, simulation languages, applications to physical, economic and social systems.

814. Advanced System Methodology and Simulation
Spring. 3(3-0) SYS 811.
Simulation of a class of time-varying distributed parameter processes; organization and design of large simulation models; optimization and parameter estimation in large simulation models; applications to economic, social and biological systems; other topics of current interest.

835. Static Optimization Methods
Summer. 4(4-0) MTH 424.
Linear and nonlinear optimization examples and applications; Kuhn-Tucker theory; saddle point optimality conditions; algorithms for problems with constraints; unconstrained optimization; introduction to search methods.

843. Ecosystem Analysis, Design and Management
Spring. 3(3-0) SYS 442. Interdepartmental with the Department of Zoology.
Groups of students from various biological and nonbiological disciplines will synthesize and analyze models of selected biological systems. Project should yield information relevant to solution of contemporary ecological problems.

ENGINEERING — EGR

College of Engineering

150. Engineers and the Engineering Profession
Spring. 3(3-0)
Overview of the engineering profession. Historical background. Engineering specialties. Engineers at work. Professionalism and ethics. Communication skills. Future trends.

200. Technology, Society and Public Policy
Winter. 3(3-0) Twelve credits from natural science or engineering. Interdepartmental with the Department of Natural Science.
Description and analysis of certain current technologies and their consequences; exploration of avenues for assessing such consequences as an aid to formulation of public policy.

290. Selected Topics
Fall, Winter, Spring, Summer. 1 to 3 credits May reenroll for a maximum of 6 credits if different topics are taken.
Experimental course developments or special topics appropriate for freshmen and sophomores.

344. Engineering Cooperative Education
Fall, Winter, Spring, Summer. Zero credits. [3 credits-See page A-1, item 3.] May reenroll for a maximum of ten terms. Employment assignment approved by College of Engineering.
Pre-professional employment in industry and government related to student's major.

390. Value Engineering
Fall. 4(4-0) Engineering Arts juniors, approval of department.
The basis of value engineering is function, value, and a group of special techniques developed to aid in isolating and identifying problems created by our complex society and technology.

401. Engineering and Public Policy
Spring. 3(3-0) Seniors or approval of department. Interdepartmental with the Department of Natural Science.
Sociotechnical assessment of impact of technology on society, with analysis of the role of engineering and natural science in contributing to public policy formulation.

ENGLISH — ENG

College of Arts and Letters

091. English for Foreign Students—Structures
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination.
Explanation and intensive practice of basic grammatical structures of English. Students are tested and then placed in small groups, from beginning to advanced, depending on their need.

092. English for Foreign Students—Speaking and Listening
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination.
Intensive speaking and listening practice of spoken English in small groups (determined by proficiency). For beginners, practice is largely drill. Advanced groups use drill, films, discussion, and practical conversations.

093. English for Foreign Students—Language Laboratory
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination.
Language laboratory practice in small groups (determined by proficiency). Beginnings review and supplement ENG 091, ENG 092. Advanced groups use carefully prepared lectures, speeches, and presentations to practice structures and vocabulary.

094. English for Foreign Students—Reading
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination.
Intensive and extensive reading in small groups (determined by proficiency). Beginners emphasize vocabulary development and practice in basic structures. Advanced classes include reading skills, wider reading, and specialized vocabulary.

095. English for Foreign Students—Writing
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination.
Frequent controlled and free writing in small groups to reduce errors and practice using structures and vocabulary to express ideas. Advanced classes include writing styles used in academic course work.

101. Responses Through Writing
Fall. 4(4-0) Arts and Letters Freshmen only. Students must enroll in and complete ENG 102 satisfactorily to make a substitution for the American Thought and Language requirement.
A writing workshop that concentrates on the students' personal writing voice and on their responses to the things, people, and institutions central to their experience.

102. Writing and Composing
Winter. 5(5-0) ENG 101; Arts and Letters Freshmen only.
A continuation of ENG 101 that develops the emphases of ENG 101 and encourages students to write in more public and objective forms—narrative, critical analysis, and issue-oriented essays.

104. Writing for Science Majors
Fall. 3(3-0) Satisfactory grade in English proficiency exam; College of Natural Science majors. Interdepartmental with the Department of American Thought and Language.
Writing workshop for science students that develops and refines composition ability.

105. The Scientist as Writer
Winter. 3(3-0) ENG 104. Interdepartmental with the Department of American Thought and Language.
Study of various types of writing by scientists—fiction, poetry, and autobiography as well as professional papers and books. Students will write frequently about the readings.

106. Introductory Scientific Writing
Spring. 3(3-0) ENG 105. Interdepartmental with the Department of American Thought and Language.
Writing of popular essays, scientific papers and reports, and other papers related to science.

200H. Honors Work
Fall, Winter, Spring. 1 to 16 credits. Approval of department.

201. Nature of Language
Fall, Winter, Spring, Summer. 3(3-0)
Various aspects of language—phonology and orthography; morphology, semantics and the lexicon; syntax; and dialects—with special reference to American English.

205. Introduction to Shakespeare
Fall, Winter, Spring. 3(3-0) Not applicable to major or minor requirements.
A study of selected plays illustrating the powers of England's greatest writer.