951C. Education Law
Fall, Winter, Summer. 3(3-0)
Approval of department.
Designed to discover general legal principles and examine laws and the making agencies that affect educators and educational institutions and appropriate means to influence law development.

951E. Educational Personnel Administration
Fall, Spring, Summer. 3(3-0) Approval of department.
Recruitment, selection, orientation, training, salary and fringe benefits, welfare, morale, negotiations, etc., to assist the administrator to function more effectively with personnel.

951F. Planning Change in Educational Organizations
Winter, Summer. 3(3-0) Approval of instructor.
Analysis of research, theory and practice of the change process in educational organizations. Planning for change and changemakers examined and tested by laboratory and field experiences.

951H. Field Research Methods in Education
Spring. 3(3-0)
Methods of interview, participant observation or observation on carrying on educational research.

951J. Conflict Management in Educational Administration
Fall, Spring. 3(3-0) Approval of department.
Theories, rationales, and strategies of conflict management. Managing conflict situations in educational environments.

951K. Externship in Educational Administration
Fall, Winter, Spring. 3 credits. May reenroll for a maximum of 27 credits. Present or past position as an educational administrator. Discussion of participants' current administrative problems and solution strategies. Faculty visits to participants' schools and speakers on issues in educational administration.

951L. Multidisciplinary Seminar in Educational Administration
Fall, Winter, Spring. 3 credits. May reenroll for a maximum of 18 credits. 9 credits of EAD 952A.
Discussion of generic problems and issues in administration identified and interpreted through selected readings and speakers from the several behavioral sciences.

960. Seminar: Continuing Education in Higher Education Institutions
Winter. 3(3-0) May reenroll for a maximum of 6 credits. Major's approval of department.
Patterns, problems, and potential for continuing education in two and four year colleges. Problems of governance, reward system, leadership roles, etc.

984. Adult Education: Program Planning
Spring. 3(3-0) EAD 860, EAD 861.
Educational program planning and development for populations that serve adult populations. Alternative program planning strategies to accommodate adult learner needs, organizational resources and desired outcomes.

970A. The Law of Higher Education
Fall, Spring. 3(3-0) Graduates in College and University Administration; others, approval of instructor.
Principles and cases of law applied to problems of governance, management, and instruction in post-secondary educational institutions. Emphasis upon personnel and student administration and equity issues.

970B. Higher Education Finance
(EAC 970B.) Fall, Spring. 3(3-0) Admission to M.A. or Ph.D. programs in the College of Education. Structures, processes and problems related to the financing of higher education in the United States. Emphasis on alternatives for the future.

971A. The Department in Higher Education
Winter. 3(3-0) Approval of instructor. The Department as an administrative structural element of the University. The duties and responsibilities of the chairperson as they relate to the management of the Department.

971B. Management Systems in Higher Education Administration
Fall, Spring. 3(3-0) Graduate students in College and University Administration; others, approval of instructor. The application of National Center for Higher Education Management Systems tools to decision making in higher education administration. Resource Requirement Prediction Model I, 6, student flow and faculty activity analysis are major tools investigated.

971C. Evaluation of Higher Education
Spring. 3(3-0) Credit. Graduate students in College and University Administration; EAD 872A or approval of instructor. Ways in which evaluation takes place in higher education; course examinations, grading, comprehensive examinations, teacher evaluation, institutional evaluation, state surveys, and regional and national studies of higher education problems.

971D. Community College Administration
Winter. 3(3-0) Graduate students in College and University Administration. Others, approval of instructor. Functional area of community college administration with emphasis upon instruction, finance and student services including the importance of local, state and federal influences.

973A. College Student Affairs Administration I
Fall. 3(3-0) Doctoral students in Student Affairs Emphasis. Others, approval of instructor.
Emphasis on planning, organization, financing, research, evaluation and administration for programs and services which exist principally to serve individual student needs counseling, orientation, health, placement, financial aids, etc.

973B. College Student Affairs Administration II
Winter. 3(3-0) Doctoral students in Student Affairs Emphasis. Others, approval of instructor.
Student organizations and activities: student union, on and off-campus living environments. Emphasis on planning, organization, financing, research, evaluation and administration of these programs and services.

973C. College Student Affairs Administration III
Spring. 3(3-0) Doctoral students in Student Affairs Emphasis. Others, approval of instructor.
Analysis of 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(0-6) 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. 1 to 9 credits. May reenroll for a maximum of 6 credits. Doctoral students in College and University Administration. Supervised and guided in-depth reading in literature and research specific to higher education administration which lead to the development of materials such as position papers, articles for publication, and grants 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. 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. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department. Supervised advanced graduate practicum, 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 AND SYSTEMS SCIENCE

College of Engineering

Electrical Engineering EE

390. Electric Circuits I
301. Electric Circuits II  
Winter, Spring. 3(3-0) E E 300, MTH 310


302. Basic Electronic Circuits  
Spring, Summer. 4(4-0) E E 301, MTH 315


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.  


305. Electromagnetic Fields and Waves I  
Fall, Winter. 3(3-0) MTH 310, PHY 298  

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

306. Electromagnetic Fields and Waves II  
Winter. Spring. 3(3-0) E E 303.  

Electromagnetic fields; EM sources, vector potential, magnetic media, induction; energy storage and 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, dielectric 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(4-0) CPS 255, MTH 214. Interdepartmental with and administered by the Department of Computer Science.  


320. Electromechanical Energy Conversion  
Fall, Spring. 3(0-3) 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 352, 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, transistors; signal conditioning; recording; data management; basic elements of control.  

355. Deterministic Communication Systems  
Fall, Spring. 3(0-3) E E 301, MTH 214. Interdepartmental with Systems Science.  

Communication systems. Representation of signals in time and frequency domain. Processing of signals by linear, simple nonlinear and time-varying 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 Circuit Design II  
Spring. 4(3-3) E E 410.  

Properties of switching algebra; combinational circuit design; fundamental-mode analysis of sequential circuits; pulse mode sequential circuits; circuit synthesis; design for testability; semi-custom circuit design.  

412. State Models, Analysis, and Simulation  
Spring. 3(0-3) SYS 311, MTH 340, MTH 334. Interdepartmental with and administered by Systems Science.  

Vector-matrix state-space models of dynamic systems, exponential matrix, transform solutions, convolution, stability, controllability, observability, simulation, computational techniques, extensions to nonlinear systems.  

413. Analysis of Control Systems  
(S131.) Fall. 4(4-0) E E 301, E E 355. Interdepartmental with and administered by Systems Science.  

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, SYS 413. Interdepartmental with Systems Science.  

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, SYS 311, SYS 413. Interdepartmental with Systems Science.  

Organization of digital control systems, classical and modern techniques for the design of digital control systems. Hardware and software considerations, emphasis on microprocessor implementation.  

416. Computers in Robotics  
Fall, 3(3-3) E E 415.  

Topics include overview of robots, sensors, homogeneous transforms, kinematics, trajectory planning, control, and introduction to vision.  

418. Introduction to Computer-Aided Circuit Design  
Fall. 3(3-0) CPS 301, E E 302.  

Introduces the techniques used for automatic formulation, analysis, optimization and layout of linear and nonlinear electronic circuits. Students will write a modest but useful analysis program package.  

419. Physical Phenomena and Electronic Instrumentation I  
Fall. 4(3-3) PHY 288 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, photomultipliers and magnetometers are examples of specific topics covered.  

421. Power System Analysis  
Spring. 3(0-3) 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(0-3) E E 320, E E 330.  

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 330.  

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) 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(2-0) CPS
Microprogrammed control; pipelining; multiprocessor and parallel processing; fault tolerant computing. Implementation of a digital system combining simulation and hardware.

430. Digital Electronics
Fall, Winter, Spring. 3(2-3) E E 230, E E 302.
Diodes and transistors as switching elements; logic families, data conversion circuits; memory circuits; digital subsystem design. Approved through Summer 1989.

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.

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

438. Transmission and Radiation Laboratory
Winter. 10(3-0) E E 435; E E 438 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. 3(3-0) E E 355.

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. Data 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. 10(3-3) E E 456; E E 457 concurrently. Experiments in 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 BJTs.

475. Electronic Devices and Circuits
Winter. 3(3-0) E E 474.
Fabrication technology; models and characteristics of BJTs, JFETs, 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 SCRs; high frequency devices and applications; transistors, impalat, transistors; 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.

495. Independent Study
Fall, Winter, Spring, Summer. 1 to 3 credits. May enroll for a maximum of 3 credits in E E 456 and SYS 456 combined. Approval of department.

499 Undergraduate Research
Fall, Winter, Spring. 1 to 3 credits. May enroll for a maximum of 6 credits in E E 499 and SYS 499 combined. Approval of department.

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 423. Interdepartmental with the Department of Computer Science.
Number systems; fast two-operand and multipoperand addition/subtraction; standard, recoded and cellular array multipliers; high performance dividers; floating-point arithmetic; error control; pipelining.

815. Advanced Computer Architecture
Fall, Winter. 3(3-0) CPS 313, CPS 423. Interdepartmental with and administered by the Department of Computer Science.
Computer architecture and design: hardware description languages; design methodologies for logic arrays and bit-slice processors; fault tolerance, testability, computer-aided design of logic circuits; automated routing algorithms.

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 asymmetrical-faults; methods and devices used in protection; pilots, breaker and carrier systems, circuit interruption, grounding.

823. Power System Stability and Control
Fall of even-numbered years. 3(3-0) SYS 528.
Analysis and simulation of small and large disturbances in power systems; generation, excitation, 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, SYS 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 4. E E 411 [I].  
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  
Fall. 4(4-0) MTH 310, MTH 334, approval of instructor. Interdepartmental with and administered by Systems Science.  
Analysis of linear continuous time and discrete time systems for both time invariant and time varying models; state space and transfer function methods; transition matrices; controllability; observability; minimal realizations; stability.

831. Active Network Synthesis  
Winter. 3(3-0) Approval of department.  

832. Switched Capacitor Circuits  
Spring of even-numbered years. 3(3-0)  
E E 480.  
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.  
Electrodynamics, 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.  

837. Electromagnetic Waves II  
Spring. 3(3-0) E E 836.  

841. Fourier Optics  
Spring of even-numbered years. 3(3-0)  
E E 455 or E E 880, E E 307 or E E 815.  
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)  
SYS 563.  
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) SYS 563 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. Interdepartmental with Systems Science.  

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

849. Microwave Electronics  
Spring of odd-numbered years. 3(3-0)  
E E 835, E E 576.  
Microwave gaseous, solid-state and vacuum devices, active microwave integrated circuits and systems, waves in solid-state plasmas and their applications, parametric amplifiers, and 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(2-0) E E 431 or CPS 423.  
Microprocessor-based system design methodology, processors, applications in signal processing control and instrumentation.

863. Analysis of Stochastic Systems  
Winter. 3(3-0) SYS 826, STT 441, MTH 424. Interdepartmental with and administered by Systems Science.  
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 semiconductors, 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. Interdepartmental with Systems Science.  
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 SYS 621 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 coupled multiprocessors, message-passing model, shared-memory model, operating systems, performance, parallel languages and algorithms.

922. Advanced Computer Systems  
Winter. 3(3-0) CPS 821, E E 813. Interdepartmental with and administered by the Department of Computer Science.  
VLSI and VLSI architectures, mapping algorithms to architectures, functional programming, dataflow computing, concurrent symbolic processing and logical programming, computer architecture for artificial intelligence, 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 425.
Current and voltage source inverter, converter and cycloconverter circuits. Pulse width modu-
lation techniques. Models of electrical machines
used in industrial drives, derivation of control
algorithms. Microprocessor based control sys-
tems.

926. Antenna Theory I
Winter of even-numbered years. 3(3-0)
E E 402.
Wire antennas as radiating, receiving and scat-
tering elements; analytical and numerical inte-
gral equation methods; coupled antennas and
arrays; transient phenomena.

927. Antenna Theory II
Spring of even-numbered years. 3(3-0)
E E 402.
Radiation by equivalent aperture fields, apen-
ture arrays, wire antennas, horn and reflector
antennas, frequency independent antennas; pat-
tern theory; scattering from various objects.

928. Advanced Topics in
Electromagnetics
Winter 2 to 4 credits. May reenroll for a
maximum of 4 credits. E E 402 and approval
of department.
Topics will be drawn from contemporary rea-
search areas such as transient electromagnetics
(TEM solutions), open-boundary waveguides,
solid-state lasers, and microwave plasma.

931. Electronic Properties of
Semiconductors
Winter of odd-numbered years. 3(3-0)
E E 474.
Advanced treatment of phenomena basic to
semiconductor materials and devices. Electronic
transport, high field effects, recombination the-
ory, electro-optical phenomena, experimental
characterization techniques.

932. Topics in Solid State Device
Research
Spring of odd-numbered years. 3(3-0)
E E 474.
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 semiconduc-
tor, and piezoelectric devices.

939. Electrodynamics of Plasmas II
Winter of odd-numbered years. 3(3-0)
E E 400. Interdepartmental with the Depart-
ment of Physics and Astronomy.
One fluid plasma model, magnetohydro-
odynamics, Maxwell's stress tensor, low fre-
quency waves, transport phenomena, Landau
damping, collision and rate coefficients. Diffu-
sion in a magnetic field; investigation of de, rf
and microwave discharges.

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

Systems Science
SYS
311. Discrete-Time Systems
Fall, Winter. 3(3-0) MTH 215.
Discrete-time system modeling, discrete-time
signals, difference equations, convolution sum-
ations, z-transform, transfer functions, stabili-
ty analysis, digital filters.

355. Deterministic Communication
Systems
(455.) Fall, Spring. 3(3-0) E E 301, SYS
115 or 116, MTH 214. Interdepartmental
with and administered by Electrical Engineering.
Communication systems. Representation of sig-
nals 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. Systems Methodology
Winter, Spring. 3(3-2) E E 370, CPS
115 or CPS 117.
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.

411. Systems Project
Spring. 2(3-0) SYS 410.
Completion of a systems study initiated in SYS
410. The project may involve the design of hard-
ware, simulation of a solution to an interdiscipli-
ary problem, or development of a solution
concept. Approved through Fall 1988.

412. State Models, Analysis, and
Simulation
Spring. 3(3-0) SYS 311, MTH 310,
MTH 334. Interdepartmental with Electrical
Engineering.
Vector-matrix state-space models of dynamic
systems, exponential matrix, transform solu-
tions, convolution, stability, controllability,
observability, simulation, computational tech-
niques, extensions to nonlinear systems.

413. Analysis of Control Systems
Fall. 4(4-0) E E 301, E E 355. Interde-
partmental with Electrical Engineering.
Control system characteristics, performance cri-
teria, 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) SYS 413. Interde-
partmental with and administered by Electrical
Engineering.
Experimental investigations of feedback sys-
tems. Study of solid state controllers. Properties
and applications of phase lock loops. Introduc-
tion to digital control.

415. Digital Control Systems
Winter. 3(3-0) SYS 411, SYS 415, SYS
413. Interdepartmental with and administered
by Electrical Engineering.
Organization of digital control systems, classical
and modern techniques for the design of digital
control systems. Hardware and software consider-
ations with emphasis on microprocessor imple-
mentation.

442. Systems Concepts for Biologists
Winter, 3(3-0) Approval of depart-
ment.
Basic concepts of systems science important to
formal analysis and control of biological com-
ponents, with emphasis on modeling and on
analysis of behavior through numerical solu-
tions.

465. Process Optimization Methods
Spring. 3(3-0) MTH 310. Interde-
partmental with and administered by the Depart-
ment of Chemical Engineering.
Methods for determining optimum design and
operating policies of systems of varying com-
plexity. Includes classical methods, mathematical
programming and modern methods. Flowsheet
optimization with process simulation packages.

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

Special Problems
Fall, Winter, Spring, Summer. 1 to 4
credits. May reenroll for a maximum of 8 credits.
Approval of department.

510. Introduction to Linear System
Theory
Fall. 3(3-0) MTH 214. May not be used
for graduate credit by Electrical Engineering
and Systems Science majors except Operations
Research/Systems Science. Interdepartmental
with the College of Social Science.
A first course in system theory for students from
a range of disciplines. Mathematical representa-
tion of system variables, transform and state
space method of analysis, introduction to control
theory, applications to physical, economic and
social systems.

511. System Methodology and
Simulation
Winter. 3(3-0) SYS 810, STT 441.
Interdepartmental with the College of Social
Science.
Problem definition, design of abstract models for
system design and control, simulation of systems
described by differential and difference equa-
tions, generation of random variables, simulat-
ion of discrete object stochastic systems, simulat-
ion languages, applications to physical, economic
and social systems.

514. Advanced System Methodology
and Simulation
Spring. 3(3-0) SYS 831.
Simulation of a class of time varying distributed
parameter processes; organization and design of
large simulation models; optimization and parame-
ter estimation in large simulation mod-
els; applications to economic, social and biologi-
cal systems; other topics of current interest.

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

827. Nonlinear Systems Analysis
Spring. 4(4-0) SYS 826, MTH 424.
Existence, uniqueness and stability in nonlinear
systems; autonomous systems and the phase
space; linearization, perturbation, describing func-
tions and harmonic balance procedures; numeri-
cal solutions.
Descriptions — Electrical Engineering and Systems Science of Courses

829. Linear Multivariable Control Systems
Winter. 4(4-0) SYE 826, STT 441, SYS 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.

835. Static Optimization Methods
Summer. 4(4-0) MTH 454.
Linear and nonlinear optimization examples and applications; barrier theory; subgradient optimality conditions; algorithms for problems with constraints; unconstrained optimization; introduction to search methods.

841. Optimization of Urban Traffic Flow
Fall of even-numbered years. 3(3-0) C E 346, STT 351 or approval of department. Interdepartmental with and administered by Civil Engineering.
Traffic flow models designed in computerized traffic control systems. Optimal traffic ramp metering algorithms. Offline and online optimization of traffic signal timing.

843. Ecosystem Analysis, Design and Management
Spring. 3(3-0) SYS 442 or ZOL 404. Interdepartmental with the Department of Zoology.
Groups of students from various biological and nontiological disciplines will synthesize and analyze models of selected biological systems. Project should yield information relevant to the solution of contemporary ecological problems.

847. Communication Engineering
Fall. 4(4-0) E E 457. Interdepartmental with and administered by Electrical Engineering.

848. Communication Theory
Spring. 3(3-0) SYS 385. Interdepartmental with and administered by Electrical Engineering.
Hypothesis testing, decision theory and parameter estimation in communications and signal processing. Optimal filtering techniques. Communication in non-Gaussian noise. Quantum detection theory.

851. Modeling of Engineering Systems I
Fall. 3(3-0) M E 455 or E E 415. Interdepartmental with and administered by the Department of Mechanical Engineering.
Modeling of engineering components and systems; mechanical, electrical, fluid, thermal, and transfer issues. Linear statespace responses, impedance methods. Simulation of linear models. Design project.

852. Modeling of Engineering Systems II
Winter. 3(3-0) M E 851. Interdepartmental with and administered by the Department of Mechanical Engineering.
Continuation of M E 851. Modeling of nonlinear dynamic systems; applications of phase-plane and linearization methods. Simulation of nonlinear systems; Design project.

863. Analysis of Stochastic Systems
Winter. 3(3-0) SYE 826, STT 441, MTH 424. Interdepartmental with Electrical Engineering.
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.

865. Digital Signal Processing
Winter. 3(3-0) E E 456 or STT 441. Interdepartmental with and administered by Electrical Engineering.
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.

900. Nonlinear Control
Fall of even-numbered years. 3(3-0) SYE 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.

910. Optimal Control Theory
Fall of odd-numbered years. 3(3-0) SYS 825, 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.

920. Dynamic System Identification
Winter of odd-numbered years. 3(3-0) SYS 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.

944. Large Scale Dynamic Systems
Spring of even-numbered years. 3(3-0) SYS 887, SYS 829.
Topics will be drawn from: model reduction and aggregation; stability of interconnected systems; multiple time scale decomposition; decentralized control; hierarchical control.

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

Engineering

Courses

150. Engineers and the Engineering Profession
Spring. 3(3-0)

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 current technology and their consequences; exploration of avenues for assessing such consequences as an aid to formulation of public policy.

ENGLISH

College of Arts and Letters

091. English for Foreign Students—Structures
Fall, Winter, Spring, Summer. Zero credits. [3 credits—See page A-1, item 3.] 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
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) with 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.

College of Engineering

150. Engineers and the Engineering Profession
Spring. 3(3-0)

150. Engineers and the Engineering Profession
Spring. 3(3-0)

College of Arts and Letters

091. English for Foreign Students—Structures
Fall, Winter, Spring, Summer. Zero credits. [3 credits—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.