877. Statistical Inference in Economics II
Winter. 3(3-0) EC 876 or approval of department. Interdepartmental with the department of Agricultural Economics, and Statistics and Probability. specification interpretation and estimation of simultaneous equation models. Nonlinear models. Bayesian approach to estimation problems. Recent developments in econometrics.

878. Statistical Inference in Economics III
Spring. 3(3-0) EC 877 or approval of department. Interdepartmental with the department of Agricultural Economics, and Statistics and Probability. Validation and application of dynamic econometric models. Bayesian approach to estimation problems. Recent developments in econometric methods and in applied econometric research.

880. Organisation and Control in the Political Economy: Institutions and Theory
Winter of even-numbered years. 4(4-0) Interdepartmental with the Department of Management. Organization and technique in choice and implementation of economic (especially planning, programming) functions of political authority.

881. Organisation and Control in the Political Economy: Selected Problems
Winter of odd-numbered years. 4(4-0) Approval of instructor. Interdepartmental with the Department of Management. Analysis of role and tasks, appropriate techniques and organizational structures of political agencies in planning and management of complex programs.

891. Topics in Applied Econometrics
Spring. 3(3-0) EC 835 or EC 877. Topics in applied econometrics with particular attention to problems of testing hypotheses in the context of economic models.

895. Graduate Reading in Economics
Fall, Winter, Spring. 3 to 16 credits. May enroll for a maximum of 12 credits. EC 812C; EC 813C.

990C. Mathematical Economics and Econometrics Workshop
Fall, Winter, Spring. 3 to 16 credits. EC 812A, EC 822; or approval of department. Interdepartmental with the Department of Agricultural Economics. Critical evaluation of research reports by staff and other students. Students writing doctoral dissertations in the appropriate areas are encouraged to participate in workshop and may do so while registered for EC 990.

990D. Economic Development Workshop
Fall, Winter, Spring. 3 to 16 credits. EC 850, EC 851, EC 852 or approval of department. Critical evaluation of research reports by staff and students. Students writing doctoral dissertations in Development are encouraged to participate in the workshop and may do so while registered for EC 990.

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

EDUCATION
See Administration and Curriculum; Counseling, Educational Psychology and Special Education; and Teacher Education.

ELECTRICAL ENGINEERING AND SYSTEMS SCIENCE

College of Engineering

Electrical Engineering

230. Digital Logic Fundamentals
Fall, Winter, Spring. 4(4-0) CPS 120 or CPS 231. Boolean algebra, combinational logic and minimization; sequential system fundamentals and components; arithmetic operations and devices; memory devices and ensembles; data conversion principles; digital integrated circuits; practical engineering design problems.

231. Computer Organization and Usage
Fall, Winter, Spring. 4(4-0) E E 230. Computer structure and machine language; microprocessors; addressing techniques; computer bus; program segmentation and linkage; microcomputer case study; survey of applications in science and engineering.

300. Electric Circuits I

301. Electric Circuits II

302. Basic Electronic Circuits
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

304. Electronics Laboratory II

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, dielectric media, capacitance, and energy storage. Boundary value problems for electrostatic fields.

306. Electromagnetic Fields and Waves II
Winter, Spring. 4(4-0) E E 305. Magnetostatic fields; EM sources, vector potential, magnetic media, inductance, and energy storage, time-varying fields and Maxwell's equations; potential theory and boundary-value problems. Energy conservation and conversion.

307. Electromagnetic Fields and Waves III
Spring. 3(3-0) E E 306, E E 308 concurrently. 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

345. Introduction to Electronic Instrumentation Systems
Fall, Winter. Spring. 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.
<table>
<thead>
<tr>
<th>Course Number</th>
<th>Title</th>
<th>Credits</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>355</td>
<td>Deterministic Communication Systems</td>
<td>3</td>
<td>0-3</td>
<td>Fall, Spring</td>
</tr>
<tr>
<td>355</td>
<td>MTH 314, 315</td>
<td>E E 301</td>
<td></td>
<td>Interdepartmental with and administered by Systems Science. 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.</td>
</tr>
<tr>
<td>412</td>
<td>State Models, Analysis, and Simulation</td>
<td>3-4</td>
<td>3-4</td>
<td>Spring</td>
</tr>
<tr>
<td>412</td>
<td>MTH 314, 315</td>
<td>E E 301</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>413</td>
<td>Analysis of Control Systems</td>
<td>Fall</td>
<td></td>
<td>4-4</td>
</tr>
<tr>
<td>413</td>
<td>E E 301, E E 335 or SYS 312</td>
<td></td>
<td></td>
<td>E E 312, 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.</td>
</tr>
<tr>
<td>414</td>
<td>Control Systems Laboratory</td>
<td>Winter</td>
<td></td>
<td>1-0</td>
</tr>
<tr>
<td>415</td>
<td>Digital Control Systems</td>
<td>Winter</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>415</td>
<td>E E 231, SYS 311, SYS 312</td>
<td></td>
<td></td>
<td>Interdepartmental with Systems Science. 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.</td>
</tr>
<tr>
<td>418</td>
<td>Introduction to Computer-Aided Circuit Design</td>
<td>Fall</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>418</td>
<td>CPS 120, E E 302</td>
<td></td>
<td></td>
<td>Introduction to computer-aided circuit design. 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.</td>
</tr>
<tr>
<td>419</td>
<td>Physical Phenomena and Electronic Instrumentation I</td>
<td>Winter</td>
<td></td>
<td>4-3</td>
</tr>
<tr>
<td>419</td>
<td>PHY 280, PHY 298 or approval of department, MTH 215, Interdepartmental with and administered by Physics. Concepts of electronics relative to use 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.</td>
<td>Winter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>420</td>
<td>Electromechanical Energy Conversion</td>
<td>Spring</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>420</td>
<td>E E 301, E E 306</td>
<td></td>
<td></td>
<td>Review of electromagnetics; design, specification, and use of d.c. machines in industrial and servo-control applications, synchronous generators and transformers for power systems; three phase power, unit notation.</td>
</tr>
<tr>
<td>421</td>
<td>Power System Analysis</td>
<td>Fall</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>421</td>
<td>E E 307, E E 420</td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>430</td>
<td>Digital Electronics I</td>
<td>Fall</td>
<td></td>
<td>3-2</td>
</tr>
<tr>
<td>430</td>
<td>E E 230, E E 302</td>
<td></td>
<td></td>
<td>Diodes and transistors as switching elements; logic families, data conversion circuits; memory circuits; digital subsystem design.</td>
</tr>
<tr>
<td>431</td>
<td>Digital Electronics II</td>
<td>Fall, Winter, Summer</td>
<td>3-2</td>
<td>E E 231, E E 430, E E 307</td>
</tr>
<tr>
<td>435</td>
<td>Microwave Circuits and Systems</td>
<td>Fall</td>
<td></td>
<td>3-3</td>
</tr>
<tr>
<td>436</td>
<td>Radiation and Reception of Electromagnetic Waves</td>
<td>Winter</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>436</td>
<td>E E 307</td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>438</td>
<td>Transmission and Radiation Laboratory</td>
<td>Winter</td>
<td></td>
<td>1-0</td>
</tr>
<tr>
<td>438</td>
<td>E E 435, E E 436</td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>456</td>
<td>Applied Probability in Communication Theory</td>
<td>Fall</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>457</td>
<td>Statistical Communication Systems</td>
<td>Spring</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>457</td>
<td>E E 468, E E 467</td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>467</td>
<td>Communications Laboratory</td>
<td>Spring</td>
<td></td>
<td>1-0</td>
</tr>
<tr>
<td>467</td>
<td>E E 456, E E 457</td>
<td></td>
<td></td>
<td>Experimental investigations on communication theory and information transmission topics from E E 455, E E 456, and E E 457.</td>
</tr>
<tr>
<td>474</td>
<td>Physical Principles of Electronic Devices</td>
<td>Fall</td>
<td></td>
<td>4-4</td>
</tr>
<tr>
<td>474</td>
<td>E E 302, E E 305</td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>475</td>
<td>Electronic Devices and Circuits</td>
<td>Winter</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>475</td>
<td>E E 474</td>
<td></td>
<td></td>
<td>Fabrication technology; models and characteristics of BJT, JFETs, and MOS devices; application to linear and digital circuits.</td>
</tr>
<tr>
<td>476</td>
<td>Applications of Electronic Devices</td>
<td>Spring</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>476</td>
<td>E E 474</td>
<td></td>
<td></td>
<td>Power devices and applications; transistors, diacs, triacs, and SCR; high frequency devices and applications; transistors, impatt, Gunn and vacuum devices; photo-devices; solar cells and LED's.</td>
</tr>
<tr>
<td>477</td>
<td>Electro-optic Devices</td>
<td>Spring</td>
<td></td>
<td>odd-numbered years, 3-0</td>
</tr>
<tr>
<td>477</td>
<td>E E 306</td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>478</td>
<td>Integrated Circuit Fabrication Laboratory</td>
<td>Winter</td>
<td></td>
<td>1-3</td>
</tr>
<tr>
<td>478</td>
<td>E E 474</td>
<td></td>
<td></td>
<td>Integrated circuit design and fabrication. Laboratory fabrication of diffused resistors, diodes, capacitors, and simple MOS or bipolar integrated circuits. Yields, testing, and economic considerations.</td>
</tr>
<tr>
<td>480</td>
<td>Integrated Circuits: Operational Amplifiers</td>
<td>Fall</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>484</td>
<td>Electronic Devices Laboratory</td>
<td>Winter</td>
<td></td>
<td>1-3</td>
</tr>
<tr>
<td>484</td>
<td>E E 474</td>
<td></td>
<td></td>
<td>Measurement of semiconductor bulk properties; device fabrication; experimental study of selected electron devices and design application based on principles discussed in E E 474.</td>
</tr>
<tr>
<td>490</td>
<td>Special Topics in Electrical Engineering</td>
<td>Fall, Winter, Spring</td>
<td>1 to 4</td>
<td>credits, May reenroll for a maximum of 12 credits. May reenroll for a maximum of 12 credits. Approval of department. Exposition of special topics in electrical engineering.</td>
</tr>
<tr>
<td>495</td>
<td>Independent Study</td>
<td>Fall, Winter, Spring</td>
<td>1 to 3</td>
<td>credits, May reenroll for a maximum of 3 credits. May reenroll for a maximum of 3 credits. Approval of department. Independent study of a topic in electrical engineering of particular interest to the student.</td>
</tr>
</tbody>
</table>
809. Undergraduate Research
Fall, Winter, Spring, Summer. 1 to 3 credits. May enroll for a maximum of 6 credits in E E 499 and SYS 499 combined. Approval of department.
Independent undergraduate research in contemporary areas of 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 432. Interdisciplinary with the Department of Computer Science.
Number systems, fast two-oprand and multiplication; standard, recoded and cellular array multipliers; high-performance dividers; floating-point arithmetic; error control; pipelining.

811. Noise and Fluctuation Phenomena
Spring of even-numbered years; Summer of odd-numbered years. 3(3-0) Approval of department.
Nyquist formulation of thermal noise; noise phenomena associated with electron tubes; transistors, beam and parametric devices; amplifiers, mixers, and detectors; techniques and equipment for noise measurements.

813. Logic Design Methodologies
Spring, 3(3-0) CPS 423 or E E 431. Interdisciplinary 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. Architecture of Computer Systems
Winter. 3(3-0) CPS 423. Interdisciplinary with and administered by the Department of Computer Science.
Overview of computer system organization; theoretical constructs of computer systems; processors; control units; memory; interconnection networks.

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; pattern recognition, sensors; sensor-based robots. Economic, political and social implications. Industrial application.

822. Analysis of Faulted Power Systems
Winter. 4(4-0) SYS 826.
Symmetrical components; models of generators, transformers, transmission lines; calculation of short circuits for symmetrical and unsymmetrical faults; system protection devices and practice.

823. Power System Stability and Control
Fall of even-numbered years. 3(3-0) SYS 826.
Analysis and simulation of small and large disturbance stability of power systems; generator excitation, voltage regulator models; design of excitation systems and power system stabilizers.

826. Advanced Linear Systems Analysis
Fall, 4(4-0) MTH 310, MTH 334. Interdepartmental with and administered by Systems Science.
Unified analysis of linear continuous-time and discrete-time systems for time-invariant and time-varying systems; mathematical descriptions, transforms, state models; transition matrix; observability and controllability; observability, stability.

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

835. Electromagnetic Theory
Fall. 3(3-0) Approval of department.

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 890, E E 807 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.

847. Communication Engineering
Fall, 4(4-0) E E 456 or approval of instructor. Interdepartmental with Systems Science.

848. Communication Theory
Spring. 3(3-0) E E 847, E E 880, E E 853. Interdepartmental with Systems Science.

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; fluid theory of plasma, waves in cold, warm and anisotropic infinite plasma; waves in bounded plasma structures, energy flow in anisotropic plasmas.

855. Microprocessor-based System Design
Spring. 2(2-6) E E 431 or CPS 432.
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
Winter. 3(3-0) E E 415, E E 456. 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 solid-state 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. Signal Analysis
Winter. 3(3-0) Approval of department. Interdepartmental with Systems Science.
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) E E 826 or SYS 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.

912. General Automata Theory II
Winter of even-numbered years. 3(3-0) E E 926. Interdepartmental with and administered by the Department of Computer Science. Reliability and redundancy of finite automata. Probabilistic sequential machines. Languages definable by probabilistic and deterministic automata. Axioms for equivalence of regular expressions.

913. General Automata Theory III
Spring of even-numbered years. 3(3-0) E E 927. Interdepartmental with and administered by the Department of Computer Science. Degrees of difficulty of computation. Models of parallel computation. Iterative automata.

921. Advanced Computer Systems I
Fall. 3(3-0) Two graduate level courses in computer system design (hardware or software). Interdepartmental with and administered by the Department of Computer Science. Models of single and multiple processors, their computational power, and measures of performance. Interconnection networks, data driven machines, and pipelines.

922. Advanced Computer Systems II
Winter. 3(3-0) E E 921. Interdepartmental with and administered by the Department of Computer Science. Design and characterization of parallel algorithms. Matching of algorithms with appropriate hardware configurations. Programming languages which support parallel computation.

926. Antenna Theory I
Winter of even-numbered years. 3(3-0) E E 836. Study of independent antennas, variable array systems, computer design and analysis. Advanced treatment of phenomena basic to semiconductor materials and devices. Electronic devices, high field effects, low noise and high gain devices, and the use of transistors, diodes and linear amplifiers.

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

928. Advanced Topics in Electromagnetics
Fall, Winter, Spring, Summer. 2 to 4 credits. May be repeated for a maximum of 4 credits. E E 835 and approval of department. Topics will be drawn from contemporary research areas such as linear and nonlinear devices, and microwave and optical systems. Other topics will be selected by the instructor.

931. Electronic Properties of Semiconductors
Fall. 3(3-0) E E 924. Advanced treatment of phenomena basic to solid state devices. Materials and devices. Device modeling, electronic transport, high field effects, recombination theory, and use of bandgap engineering. Characterization techniques.

932. Topics in Solid State Device Research
Fall and Spring of odd-numbered years. 3(3-0) E E 927. Relationship of solid state device structure and material properties to device performance. Topics selected from current device research areas and vary with year. Examples are materials, amorphous semiconductor, and piezoelectric devices.

941. Systems Project
Spring. 3(3-0) E E 311. The systems approach in multidisciplinary large scale problem solving. The development of useful systems analysis tools, systems design, feasibility study; computer simulation for feasibility evaluation.

946. Biological and Ecological Concepts for Engineers and Mathematicians
Winter. 3(3-0) Approval of department. Interdepartmental with and administered by the Department of Zoology. Biological and ecological concepts important to formal analysis of living systems, vital properties, processes, and limitations; population dynamics, selection competition, and predation; ecological community structure and function; industrialized ecosystem.

950. Systems Methodology
Winter. 3(3-0) MTH 113, CPS 110 or CPS 120. The systems approach in multidisciplinary large scale problem solving. The development of useful systems analysis tools, systems design, feasibility study; computer simulation for feasibility evaluation.

942. 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 analysis of behavior through numerical solutions.
465. Process Optimization Methods  
Fall. 3(3-0) MTH 310. Interdepartmental with and administered by the Department of Chemical Engineering.  
Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods.

485. Independent Study  
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 6 credits in SYS 495 and E E 495 combined. Approval of department required.  
Independent study of a topic in systems science of particular interest to the student.

499. Undergraduate Research  
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 8 credits. E E 495 and E E 456. Interdepartmental with and administered by the Department of Chemical Engineering.  
Independent undergraduate research in contemporary areas of systems science.

801. Special Problems  
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 6 credits. Approval of department.

810. Introduction to Linear System Theory  
Fall. 3(3-0) MTH 214. May not be used for graduate credit by College of Engineering majors except Operations Research/Systems Science. Interdepartmental with the College of Social Sciences.  
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. Interdepartmental with the College of Social Sciences.  
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.

813. System Project  
Spring. 3(1-5) SYS 811. Interdepartmental with the College of Social Sciences.  
Individual or team application of simulation methods to system design and management.

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.

820. Advanced Real Systems Analysis  
Fall. 4(4-0) MTH 310, MTH 324. Interdepartment with Electrical Engineering.  
Unified analysis of linear continuous-time and discrete-time systems for both time-invariant and time-varying models; mathematical descriptions, transforms, state models; transition matrices; solution techniques; controllability; observability; stability.

825. Nonlinear Concepts in Systems Science  
Winter. 4(4-0) SYS 826.  
Existence, uniqueness and stability in nonlinear systems; autonomous systems and the phase space; linearization, perturbation, describing functions and harmonic balance procedures; numerical solutions.

829. Modern Control Systems  
Spring. 4(4-0) STT 441. SYS 826.  
Stochastic processes and white noise; analysis of linear continuous-time control systems; state feedback design, state observer design; optimal linear control and Kalman filter; linear discrete-time control systems.

835. Nonlinear Optimization Models  
Summer. 4(4-0) MTH 315, MGT 834 or CHE 465. Students may not receive credit for both SYS 835 and MGT 835.  

838. Feasibility Analysis of Energy Systems  
Spring. 3(3-0) STT 441.  
Methods for selecting energy conversion and transmission facilities with emphasis on electric utilities. Demand forecasting system reliability, selection of size, type and location of conversion facilities; cost analysis.

841. Optimization of Urban Traffic Flow  
Fall of odd-numbered years. 3(3-0) Approval of department. Interdepartmental with Civil Engineering.  
Traffic flow models used in design of computerized traffic control systems. Optimal freeway 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 nonbiological disciplines will synthesize and analyze models of selected biological systems. Project should yield information relevant to solution of contemporary ecological problems.

847. Communication Engineering  
Fall. 4(4-0) E E 456 or approval of instructor. Interdepartmental with and administered by Electrical Engineering.  

848. Communication Theory  
Spring. 3(3-0) E E 847, E E 880, E E 963. Interdepartmental with and administered by Electrical Engineering.  
Hypothesis testing, decision theory and parameter estimation in communications and signal processing; noise theory and coding; communication in non-white noise. Communication in non-Gaussian noise. Quantum detection theory.

851. Modeling of Engineering Systems I  
Fall. 3(3-0) M E 425 or E E 415, Interdepartmental with and administered by the Department of Mechanical Engineering.  
Modeling of engineering components and dynamic systems; mechanical, electrical, fluid, thermal, and transducer effects. Linear state-space 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.  

863. Analysis of Stochastic Systems  
Winter. 3(3-0) E E 415, E E 456. 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.

880. Signal Analysis  
Winter. 3(3-0) Approval of department. Interdepartmental with and administered by Electrical Engineering.  

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

947. Topics in Communications  
Fall of odd-numbered years. 3(3-0) May reenroll for a maximum of 6 credits. E E 848. Interdepartmental with and administered by Electrical Engineering.  
Advanced treatment of a topic or group of topics of current research interest in the field of communications, information theory and signal processing.

961. Optimal Control Theory  
Fall. 3(3-0) SYS 827, MTH 426.  
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.

962. Computational Techniques for Optimal Control  
Winter of odd-numbered years. 3(3-0) SYS 861.  
Computational methods of optimal controls, necessary conditions, variation of extremals, quasilinearization, gradient projection, dynamic programming, convexity techniques, support functions for reachable sets, current literature.

963. Dynamic System Identification and Control  
Spring of odd-numbered years. 3(3-0) SYS 863, SYS 829.  
System identification; dynamic programming; stochastic and adaptive control. Topics under identification include review of statistics background, dynamic system models, identification methods, recursive algorithms, input design, and structure discrimination.
ENGLISH

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, film, 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 emphasis 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.

126. The Writer and Literature
Fall, Winter, Spring, Summer. 3(3-0) The first term of ATL 121 or above or ENG 101. Modern literature from the writer's perspective. Students also write their own critical and creative work, using journal method.

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.

206. Forms of Literature: Fiction
Fall, Winter, Spring. 3(3-0) Open to Freshmen. Major forms of prose fiction, designed to reveal artistic problems met and solved by these forms. Prepares students for advanced literary study by acquainting them with the conventions of various literary forms, by providing a critical vocabulary and by furnishing experience in reading and writing critical evaluations of outstanding literary works from all historical periods.

207. Forms of Literature: Drama
Fall, Winter, Summer. 3(3-0) Open to Freshmen. Major forms of drama, designed to reveal artistic problems met and solved by these forms.

208. Forms of Literature: Poetry
Fall, Winter, Spring. 3(3-0) Open to Freshmen. Major forms of poetry, designed to reveal artistic problems met and solved by these forms.

210. Introduction to the Study of Literature I
Fall, Winter. 4(4-0) English majors or prospective English majors. Exploration of the major forms of literature, the aims and process of literary study, the cultural and personal functions of literature, and the role of literary study in the University.