ECE 602 Application of Integer Optimization to Engineering Design (0.50) LEC  
Linear and nonlinear classes of optimization problems, integer programming problems. NP-complete problems. Modelling problems as integer or mixed-integer problems, graph colouring, maximum matching, network flow and applications. Node packing, knapsack and travelling salesman formulations, decreasing search space by better formulations. Bounds, variable priorities, special ordered sets and search algorithms.

ECE 604 Stochastic Processes (0.50) LEC  
Review of theory of random variables and the introduction of random vectors; characteristic functions, conditional quantities and convergence. Random processes in continuous and discrete time, basic properties and types including the vector Gaussian process, correlation and power spectra. Linear operations on multi-dimensional continuous processes and discrete time series.

ECE 605 Queueing Systems (0.50) LEC  

ECE 610 Broadband Communication Networks (0.50) LEC  
This course is concerned with the fundamentals of broadband communication networks including network architecture, Switch fabrics, design methodology, traffic management, connection admission control (CAC), usage parameter control (UPC), flow and congestion control; capacity and buffer allocation, service scheduling, performance measures, performance modeling and queueing analysis.

ECE 611 Digital Communications (0.50) LEC  
Representation of bandpass signals and systems, modulation and demodulation for the additive white Gaussian noise channel, optimal demodulation for signals with random phase, noncoherent detection for binary and M-ary orthogonal signals, hard and soft decision decoding for linear codes, concatenated codes, performance of coded modulation systems, characterization of fading multipath channels, diversity techniques, performance of coded systems on fading channels, direct sequence and frequency hopped spread spectrum systems.

ECE 612 Information Theory (0.50) LEC  
An introduction to information measures, entropy, mutual information and information divergence, noiseless codes and the noiseless coding theorem, channel capacity for discrete and continuous channels, randomly chosen code words, the noisy coding theorem, error rate exponents, computational cut-off rate and its application to digital communications.

ECE 613 Digital Speech Processing (0.50) LEC  
Speech generation and perception, articulatory description of speech, acoustic phonetics, linear prediction for speech signals, digital representation of the speech waveform, speech recognition, speech enhancement, future directions in speech processing.

ECE 614 Communications Over Fading Dispersive Channels (0.50) LEC  
Course ID: 000772
Overview of mobile communications, the characterization and modeling of time–variant fading and/or dispersive channels, digital communication system performance over fading dispersive channels, diversity reception, optimum receiver, trellis–coded modulation (fundamentals, performance evaluation and applications to mobile communications), spread spectrum systems, and code division multiple access (CDMA).

**ECE 616 Principles of Data Communication (0.50) LEC**
Course ID: 000773
This course is concerned with the transmission and reception of signals transmitted over a dispersive channel. It starts by defining the necessary conditions for intersymbol interference free transmission. This will then be followed by a treatment of error performance in the absence and the presence of inter–symbol interference. The effects of channel impairment, the criteria for optimum reception and channel equalization for intersymbol interference removal will be discussed. Spectral shaping (or partial response) techniques will be introduced, which will then be followed by a treatment on digital modulation techniques, including psk, dpsk, fsk and M–ary digital phase modulation.

**ECE 617 Data Compression with Applications to Speech and Image Coding (0.50) LEC**
Course ID: 000774
This course consists of three parts: Part 1 will be concerned with the definitions of entropies as information measures and the derivation of the rate distortion function of Gaussian sources, which will form the basis for performance comparison. Part 2 will discuss the derivations, design and performance of certain compression techniques, including dpcm/entropy coding, predictive coding, linear predictive coding (LPC), adaptive predictive coding (APC), vector quantization, and tree and trellis coding. Part 3 will consider applications of compression techniques to speech and image processing.

**ECE 621 Computer Organization (0.50) LEC**
Course ID: 000777
Organization of high performance digital computers, high speed arithmetic algorithms, control unit and data flow organization. Pipeline systems. Stack machines, associative processors, parallel processors. Performance evaluation.

**ECE 628 Computer Network Security (0.50) LEC**
Course ID: 000780

**ECE 629 Computer Arithmetic (0.50) LEC**
Course ID: 000781

**ECE 631 Microelectronic Processing Technology (0.50) LEC**
Course ID: 000783
Sources and purification of materials, crystal structure, diffusion, oxidation, ion implantation, alloying epitaxy, impurity profiling methods, metallisation, photo lithography. Technologies for VLSI.

**ECE 633 Bipolar Devices (0.50) LEC**
Course ID: 000785
Review of the semiconductor equations, d.c. and high frequency characteristics of PIN diodes (power rectifiers, microwave switches and limiters, step recovery diodes, varacter diodes), photo detector diodes, solar cells. Advanced analysis of the bipolar transistor: high current and high frequency effects. CAD models. VLSI considerations.
ECE 634 Field Effect Devices (0.50) LEC
MOSFET Devices. Theory of operation of VLSI MOSFET's. Short channel effects, subthreshold effects, scaling, nonuniform doping, subthreshold control, HMOS, DMOS, VMOS. MIS diode and charge-coupled devices. JFET and MESFET basic device characteristics, device models, V-grove FET, multichannel, metal and semiconductor contacts. Schottky effect. Schottky device.

ECE 635 VLSI Systems Design (0.50) LEC

ECE 636 Analog MOS and Bipolar Integrated Circuits (0.50) LEC
Design of MOS and bipolar analog integrated circuits at the transistor level, topics on analog and mixed analog/digital subsystems such as switched capacitor filters and analog-digital converters, practical design problems.

ECE 637 Design of VLSI MOS Integrated Circuits (0.50) LEC
DC and AC characteristics of MOSFETs for VLSI. Scaling effects. MOSFETs in digital circuit design; static and dynamic circuits. NMOS and CMOS. DC and transient analysis. Memory cells. MOSFETs in analog circuit design. Differential stages. Digital and analog circuit applications.

ECE 638 Semiconductor Microtransducers (0.50) LEC
Overview of basic physical processes in semiconductors and their interactions with thermal, radiant, mechanical, or chemical input signals. Review of microtransducer materials and technologies. Principles and operation of integrated thermal sensors (thermistors, thermopiles, active IC elements, pyroelectric devices), radiant sensors (optoelectronic, infrared and radiation sensors), magnetic sensors (Hall devices, magnetoresistors, magnetotransistors), (mu)mechanical sensors (piezoelectric and piezoresistive devices, flow sensors and resonant structures), chemical sensors (ion, gas and humidity sensors, CHEMFETs, biosensors, SAW devices), and micro-actuators ((mu)valves, (mu)pumps, (mu)motors). Overview or pertinent interface and modelling techniques.

ECE 639 Characteristics &Applications of Amorphous Silicon (0.50) LEC

ECE 644 Computer Aided Circuit Analysis and Design (0.50) LEC
Formulation of equations for arbitrary circuits, active network analysis; sensitivity calculations in the frequency domain; simple integration methods for time domain solution; numerical laplace inversion for transient solution of linear lumped and distributed networks; solution of nonlinear circuits; detailed time domain solution of nonlinear networks; simulation of switched networks in time domain; introduction to switched capacitor networks; iterative simulation methods.

ECE 645 Analog Filter Design (0.50) LEC
Active network analysis, concepts of sensitivity; bilinear and biquad sections; cascade filter design; approximation methods; Butterworth, Chebyshev, Inverse Chebyshev, and Elliptic filters; frequency transformations; passive LC ladder filters;
negative impedance converter, FDNR, and gyrator realizations; multi loop feedback and feedforward realization, leap frog realization; introduction to switched capacitor filters.

ECE 647 Circuit Layout Techniques (0.50) LEC
Analysis and design of efficient (fast) algorithms for solving fundamental problems that arise in circuit layouts, partitioning, placement, and global and detailed routing, large-scale combinatorial, graphical and mathematical programming models and techniques. Course ID: 000792

ECE 652 Parallel Programming (0.50) LEC
Concurrent and parallel programming languages, programming languages for array and vector processors, shared memory and message passing paradigms, distributed processing paradigms, synchronization, semaphores, monitors, rendezvous, remote procedure calls. Course ID: 000795

ECE 661 DC &Flexible AC Transmission (0.50) LEC
Application of state-of-the-art high power electronics to power transmission systems. Emphasis on direct current systems within ac transmission systems and high power electronic controllers for enhancing ac system performance (FACTS: Flexible AC Transmission Systems). FACTS include controlled series capacitors, static compensators (STATCOM), unified power controllers and static phase shifters. Course ID: 000797

ECE 662 Power Systems (0.50) LEC
This is intended to be a broadly based course covering planning, operations, performance and analytical techniques in power generation, transmission and distribution. The consideration of characteristics, models and performance of individual items of power equipment includes recent developments such as static var systems. Reference is also made to developments in system control for normal, emergency and restorative operation together with the accommodation of operational problems such as subsynchronous resonance. Course ID: 000798

ECE 663 Energy Processing (0.50) LEC
This course is intended to embrace power electronic aspects together with the broader issues of the systems of energy processing for emerging technologies. Within this framework, topics include performance, selection and optimization of power semiconductor devices including thyristors, GTOs, triacs, BJTs, MOSFETs, IGBTs and MCTs; classification, circuits and performance of converting circuits including rectifiers, inverters, choppers and cycloconverters; control and protection of conversion circuits; requirements and constraints of energy processing systems such as variable speed drives, high energy battery installations, transportation, solar and wind generators and industrial processes. Course ID: 000799

ECE 664 Power System Computer Application (0.50) LEC
Attention is given to the application of computers for both real-time and off-line applications. Control, protection and performance monitoring of components are related to microprocessor developments. Computers are considered in the broader aspects of system control. For off-line applications, computational aspects of load flow and system dynamics are studied along with simulation programs such as EMTP. The impact of digital processing on derivation of system quantities as opposed to continuous analog devices is discussed. Course ID: 000800

ECE 665 High Voltage Engineering Applications (0.50) LEC
This course deals with the new emerging technology in high voltage engineering. It is divided into five parts. The first part of the course is a review of the basic fundamentals of high voltage engineering. The second part deals with the new techniques in partial discharge measurements. The third part of the course deals with measurements of charge distribution in solid dielectric.
The fourth part of the course discusses the optical fiber based monitoring techniques of the high voltage high power equipment. The last part of the course deals with the application of high voltage engineering in power systems.

**ECE 669 Dielectric Materials (0.50) LEC**


**ECE 671 Microwave and RF Engineering (0.50) LEC**

Fundamentals of microwave and RF circuit analysis, design and measurements; Generalized transmission line analysis; S-parameters; Coupler and filter design; Diode-detectors, and mixers; Low-noise and power amplifiers, oscillators; Computer aided design of RF circuits.

**ECE 672 Optoelectronic Devices (0.50) LEC**

Overview of optical properties of semiconductors and elements of plane wave propagation, theory and design of light emitting diodes, laser diodes, and detectors, optical spectra and transitions, spontaneous and stimulated emission, population inversion, carrier and optical confinements in heterostructures, quantum-well lasers, optoelectronic detectors, bandgap engineered graded structures, staircase type or superlattice structures for detectors, detailed quantum efficiency calculations and detector noise considerations, Introduction to monolithic integrated circuits.

**ECE 674 Analysis and Computation of Electric and Magnetic Fields (0.50) LEC**

This course studies the static fields, capacitance and inductance by the following techniques. Classical image technique, variable separation, conformal and Schwarz-Christoffel transformations, the moment method, the optimized-simulated sources method, the variational techniques and the upper and lower bounds.

**ECE 675 Radiation & Propagation of Electromagnetic Fields (0.50) LEC**

Mathematics of time varying electromagnetic fields, linear antennas self and mutual impedance, aperture antenna, wave diffraction theory, geometrical theory of diffraction (GTD).

**ECE 678 Fourier Optics and Optical Signal Processing (0.50) LEC**


**ECE 682 Multivariable Control Systems (0.50) LEC**

An introduction to control theory for linear time-invariant finite-dimensional systems from both the state-space and input-output viewpoints. State-space theory: the concepts of controllability, observability, stabilizability, and detectability; the pole-assignment theorem; observers and dynamic compensation; LQR regulators. Input-output theory: the ring of polynomials and the field of rational functions; the algebra of polynomial and rational matrices; coprime factorization of transfer matrices; Youla parametrization, introduction to optimal control.
Estimation theory, linear and nonlinear regression, numerical techniques for parameter estimation for static and dynamic models, the Kalman filter and extensions, stochastic approximation, empirical dynamic models – especially for linear sampled data systems with stochastic inputs.

**ECE 685 Stochastic Processes for Dynamical Systems (0.50) LEC**  
Course ID: 000813  

**ECE 686 Filtering and Control of Stochastic Linear Systems (0.50) LEC**  
Course ID: 000814  
This is a course on continuous–parameter state estimation and control for stochastic linear systems. It is based on a single unifying theme, namely that state estimation in linear systems is equivalent to projection onto a closed linear subspace generated by an observation process in a Hilbert space of random variables. This formulation of state estimation leads to the innovations theorem of Kailath, and this in turn has a number of corollaries of considerable practical importance, such as the Kalman–Bucy filtering formulae and the Rauch–Tung–Striebel prediction formulae which are much used for example in problems of inertial guidance and control in aerospace, in stochastic optimal control, and (more recently) in econometrics.

**ECE 687 Robot Dynamics and Control (0.50) LAB,LEC**  
(Cross–listed with ECE 486)  
Course ID: 004816  

**ECE 688 Nonlinear Systems (0.50) LEC**  
Course ID: 000815  
Equilibrium points, linearization; second order systems; contraction mapping principle; existence and uniqueness of solutions to nonlinear differential equations; periodic solutions; Lyapunov stability; the Lure problem; introduction to input–output stability, introduction to nonlinear control techniques.

**ECE 700s**

**ECE 700 Special Topics in Electrical and Computer Engineering (0.50) LEC**  
Course ID: 010652  
1 Opt–based Appr Solv Hard Probl  
2 Intro to Optimization

**ECE 710 Special Topics in Communications and Information Theory (0.50) LEC**  
Course ID: 010653  
1 Wavelets in Signal Processing  
2 Wireless Communication Network  
3 Spread Spectrum Communications  
4 Sequence Design and Crypt  
5 Algebraic Coding Theory  
6 Photonic Networking
7 Space-Time Coding for Wire Com
8 Medical Imaging
9 Dielectric Materials
10 Satellite Sys~Design &Applctn
11 Estimation & Detection Theory

ECE 711 Special Topics in Digital Communications (0.50) RDG
Course ID: 011246

ECE 720 Special Topics in Computers and Digital Systems Software (0.50) LEC
Course ID: 010654
1 Multiproc & Parall Proc Struc
2 Cryptographic Computations
3 Computer Networks
4 Innov: Microprocessor Design

ECE 725 Computer~Aided Verification (0.50) LEC
Course ID: 011295
(Cross~listed with CS 745)
Application of formal methods to the verification of computer~based systems. Algebraic and automata preliminaries.
Temporal logic and model checking. Decision procedures. Mechanized theorem proving. Advanced topics chosen by the
instructor.

ECE 730 Special Topics in Solid State Devices (0.50) LEC, RDG
Course ID: 000827
1 Semiconductor Physics
2 Low Volt CMOS/BiCMOS VLSI
3 Semiconductor Characterization
4 Large Area Thin Film Electron
5 Advanced Analog Int Circuits
6 Single-Chip Imaging Systems
7 RFIC Technology
8 RF Systems and Circuits
9 VLSI Quality, Reliability Eng
10 Adv Tech for Semi Proc
11 Phy & Mod Semi~cond Dev
12 Low~Voltage SOI CMOS VLSI
13 Nanoelectronics
14 Microsystems Technology
15 High~Performance CMOS Circuits
16 Embedded Semiconductor RAM
17 Physof Semiconductor Dev

ECE 731 CCD Image Sensors (0.50) LEC
Course ID: 000828
As the cost of computing decreases at a phenomenal rate, the use of large format CCD area image sensors increases.
Applications of CCD image sensors include industrial such as web inspection, document scanning, manufacturing product
inspection for quality and process control, manufacturing product sorting and many other industrial applications. Multimedia
and computers increasingly use their CCD image sensors or active pixel CMOS type image sensors. This course will start with
the basic theory of CCD image sensors and graduate to CMOS type solid state image sensors. It will concentrate on the state
of the art of this field and will deal with the basic device theory, the circuit design and architectures. Photosensitivity, noise,
modulation transfer function and other aspects of spatial resolution will be covered. Related Background: Esemiconductor and
circuit undergraduate courses.

ECE 732 Simulation of Semiconductor Microtransducers (0.50) LEC
Transduction principles of thermal, radiant, magnetic, mechanical, and chemical microsensors and microactuators, model
equations accounting for the various signal interactions, modeling approaches, numerical solution schemes, simulation
eamples, mixed–signal simulation techniques. Required Background: Knowledge of basic (undergraduate) numerical
methods and device physics.

ECE 733 Advanced Bipolar Devices (0.50) LEC
Photodector Diodes and solar cells, photoductor structures; transient and high frequency behaviour of diodes, narrow base
diodes, P+NN+ and PIN diodes, transient turn–off behaviour of PIN step–recovery diodes, open circuit voltage decay
transient, large signal sinusoidal high frequency behaviour; discrete bipolar transistor structures, the microwave power
transistor, the silicon controlled rectifier, other three–terminal high voltage switching devices; advanced technology devices,
summary of advanced fabrication techniques, polysilicon and double polysilicon structures, experimental structures using
polysilicon and etch processes, oxide isolation, schottky transistor logic and the effect of oxide isolation, the P++ extrinsic
base region, gallium arsenide and heterojunction bipolar transistors; numerical analysis and CAD models of bipolar
transistors.

ECE 738 Low Power VLSI Circuits for Wireless Communication (0.50) LEC
This course covers the system level design of integrated circuits for wireless transceivers. Specific mixed analog/digital
circuits such as: mixers, A/D and D/A converters (Nyquist rate and oversampled) for IF digitizing as well as switched
capacitor filters for IF and baseband processing will be studied. Related Background: Basic knowledge of Analog Integrated
Circuits.

ECE 740 Special Topics in Networks and Systems (0.50) LEC
1 ATM Network Performance

ECE 741 AHDL Modeling of Circuits and Systems (0.50) LEC
The separation of models from the simulation engine. The interaction of models and the simulation engine. Basics of a
simulation engine. Mathematical tools for modeling. Modeling using modern Analog Hardware Description Languages
(AHDLs). AHDL applications to: large circuit simulation, efficient model development/verification, specialized simulators.

ECE 750 Special Topics in Computer Software (0.50) LEC, RDG
1 Methods Software Req Eng
2 Software Reliability Eng
3 Software Re–Engineering
4 Prot, Soft, Iss Mob Systems
5 Dist.Centric Computing
6 Pervasive Computing
7 Software Syst Family Program
8 Meta Programming Systems
ECE 752 Software Architecture & Design (0.50) LEC
Advanced study of software design and architecture; representation of architecture/design; software design methods; patterns in software design; analysis, assessment, verification and quality control for software design; case studies, current research issues and challenges. Related Background: Basic exposure to programming using C or C++, previous graduate or undergraduate course in software specifications, or software engineering should be sufficient.

ECE 753 Parallel and Distributed Systems (0.50) LEC
Models for concurrent programming; data programming; data parallel models for SIMD and MIMD computers; explicit, semiautomatic, and automatic approaches; data parallel compilers; software engineering issues such as program and data partitioning; task mapping and scheduling, concurrent program design, testing and debugging of concurrent programs, performance tuning, etc. Related Background: Basic exposure to programmin using C or Fortran, previous graduate or undergraduate course in operating system or concurrent programming would be helpful.

ECE 754 Concurrent Logic Languages with Real-Time Constraints (0.50) LEC
Lambda calculus; predicate logic; inference engines (Warren abstract machine); Prolog; concurrent logic programming; parallelism; concurrent constraint logic programming; compile and execution time environments; real–time constraints. Related Background: A certain maturity in compilers, operating systems, and abstract data structures, prior knowledge of Prolog is helpful.

ECE 755 Software Testing (0.50) LEC
The application of formal test methods based on the structural and behavioural properties of software systems at the unit integration, and system testing levels; for conventional and object–oriented implementations. Related Background: Prior knowledge of a programming language and a certain maturity in compilers, operating systems, abstract data structures, object–oriented and programming skills.

ECE 760 Special Topics in Power Systems and High Voltage Engineering (0.50) RDG
1 Power System Protection
2 Appl of Art Int to Pow Sys
3 Power System Transients
4 Operation Restructured Pow Sys
5 Power Sys Model & Stab Analy
6 Power Sys Mgmt & Elec Market
7 Power Electronic Converters
8 Electro/Comp Power Systems
9 Dielectrics & Elect Insulation

ECE 761 Applied Nonlinear Systems Theory (0.50) LEC
This course concentrates in the numerical techniques used for the study of various stability issues in nonlinear systems characterized by sets of differential equations and algebraic constraints. Lyapunov stability theory is used to investigate in detail regions of attraction and their dynamic manifolds. Local and global bifurcations in nonlinear systems are studied together with the numerical techniques used to detect them. Different mechanisms that lead nonlinear systems to chaotic
behaviour are also investigated. All concepts are illustrated using power system examples.

ECE 762 Optimization Techniques in Power Systems (0.50) LEC

In this course basic concepts on power system analysis, nonlinear programming and optimality conditions are reviewed. Factorization and orthogonal methods for the solution of linear systems and least-square problems are also discussed. Optimization techniques such as linear programming, interior point methods, quadratic and dynamic programming are analyzed in detail. Other topics of study include advanced load−flow methods, sparsity techniques and optimal ordering, power system state estimation, security−constrained economic dispatch, reactive power dispatch, and optimal capacitor allocation.

ECE 765 Distribution Systems Engineering (0.50) LEC

This course includes topics on distribution system planning, load forecasting, distribution system automation, design of subtransmission lines and distribution substations, design considerations for primary and secondary systems, voltage drops and power−loss calculations, application of capacitors to distribution systems, distribution system voltage regulations, distribution system protection and system reliability.

ECE 770 Special Topics in Antenna and Microwave Theory (0.50) LEC

1 Microwave Engineering
2 Co Theo Sig Proc Ant Sys
3 Adv Top in Optoelectronics
4 Comp Meth for Eng Electro
5 App High Temp Superconduc
6 Photonic Com Sys &Devices
7 Micro Filters for Cmmctn Syst
8 Appl High Temp Superconduct
9 Adv Antenna &EM Wave Structs
10 EM Boundary−Value Problems
11 Quantum Info Pocesng Devices
12 FT/MM Techniques for EM Propg
13 Quantum Information Devices

ECE 780 Special Topics in Control (0.50) RDG

1 Sampled Data Controlled System
2 Discrete Event Systems
3 Robot Dynamics &Control
4 Robust Control

ECE 781 Adaptive Control (0.50) LEC

Adaptive control is an approach used to deal with the unavoidable problem of plant uncertainty. Rather than providing a fixed linear time−invariant controller, this approach yields a controller whose parameters change with time. This controller typically consists of a linear time−invariant compensator together with a tuning mechanism which adjusts the controller gains; typical control objectives are stabilization and tracking. The bulk of the course will be centered on an identifier based approach. Here one chooses a model for the plant, whose parameters are unknown, and the plant parameters are recursively estimated; controller gains are computed assuming that the present estimate is correct. We first study algorithms to carry out parameter estimation, we then look at various control laws, and finally these are combined to yield an adaptive controller. Related Background: knowledge of linear system.
ECE 784 Introduction to Stochastic Calculus (0.50) LEC

Monotone and Dynkin class theorems, introduction to discrete and continuous parameter martingales, stochastic integrals, Itô formula, Girsanov transformation. Held with: STAT 902.