Course Outcomes for Electrical and Computer Engineering Courses
Last Update: May 2006

ECE 1010 Introduction to ECE

1. Identify and explain the operation of common electronic components.
2. Use a variety of electronic prototyping techniques.
3. Use basic lab equipment: oscilloscope, etc.
4. Work in teams to complete a project.
5. Understand how the upper-division courses relate to each other.

ECE 2200 Electrical Engineering for Nonmajors

1. Students will become familiar with DC circuits, including Ohm's law, Kirchoff's voltage law, and Kirchoff's current law.
2. Students will become familiar with electronic circuits, including basic operation of diodes, BJTs, and op-amps.
3. Students will become familiar with digital circuits, including basic gates (and/or/not/nand/etc.), Karnaugh maps, and simple state machine design.
4. Students will become familiar with basic power concepts.

ECE 2410 Electrical Circuits

1. Understand fundamentals, including Ohm's, Kirchoff's and conservation laws.
2. Have the ability to write and solve loop current and node voltage equations for arbitrary DC, AC and transient response of networks including resistors, capacitors, inductors, dependent and independent sources.
3. Ability to formulate Norton and Thevenin equivalent circuits at an arbitrary interface set of points for complex networks including dependent and independent sources.
4. Ability to solve for currents, voltages, and power in circuits containing ideal op-amps in basic inverting, noninverting, summing and differencing configurations. Ability to design simple op-amp circuits.
5. Ability to find the time constants, initial and final values, and complete responses for first-order RC and RL circuits driven with step and pulse sources.
6. Ability to use lab instruments including oscilloscope, power supply, multimeter and function generator.
7. Ability to use circuit simulation/anaysis software for DC, sinusoidal steady-state, and transient analysis.

ECE 2530 Digital Circuits Upon complete of ECE 2530 a student will be able to:

1. Demonstrate understanding of Boolean algebra and basic digital logic.
2. Demonstrate understanding of combinational logic
3. Demonstrate understanding of sequential logic
4. Simulate combinational and sequential circuits in a modern simulation system
5. Complete a simple top-down digital design using a mixture of standard logic components and programmable devices which can be programmed with a modern hardware description language.
6. Partition the design into modules, create the modules from standard logic devices or by programming programmable devices.
7. Verify that their designs function correctly using simulation.

ECE 3260 Science of Sound

1. Look at the field of acoustics from eight different points of view.
2. Use a new vocabulary to discuss topics in acoustics.
3. Use math to solve problems in acoustics

ECE 3410 Electronic Systems I

1. Students will be able to understand the operation of the following fundamental devices of discrete and IC microelectronics: amplifiers, operational amplifiers, diodes, MOSFETS, CMOS inverters.
2. Students will be able to design, simulate, analyze, and test basic analog and digital circuits containing the fundamental devices listed above.
3. Students will be able to understand the design, operation, and characterization of basic amplifiers, using FET devices and incorporate these amplifers into system design, based upon terminal characteristics.
4. Students will be able to use appropriate modeling software to model, simulation, analyze, and optimize the devices and circuits of this course.

Or: (There is another set of outcomes. While there is considerable overlap, the discrepancy and different emphasis needs to be resolved.)

1. Understanding of ideal and real amplifier models, including gain/bandwidth trade-off, slew rate, frequency compensation, offset errors, saturation effects, nonlinearity, and small-signal models.
2. Understanding of diode models at several levels of abstraction and familiarity with nonlinear circuit analysis.
3. Knowledge of MOS device behaviors, with substantial experience analyzing large- and small-signal models in circuits with one and two MOS devices. Students will learn to recognize and analyze devices operating in the linear, triode, and saturation regions.
4. Experience designing MOS amplifier gain stages, including common-source, common-drain, and source-follower configurations. Students are also introduced to differential pair circuits and learn to predict the gain, output resistance and bandwidth of these circuits.

5. Introduction to the design of multistage amplifier circuits including op amps.

6. Experience with rigorous circuit design flow, including detailed analysis, careful choice of approximation, simulation using SPICE, and laboratory verification.

ECE 3620 Circuits and Signals

1. Demonstrate understanding of system concepts such as linearity, time-invariance, stability, etc. Demonstrate understanding of basic signals used for analysis such as unit impulse, unit step, complex exponential, etc.

2. Demonstrated ability to model electrical circuits using differential equations.

3. Be able to determine system response using convolution.

4. Demonstrate ability to convert differential equations to Laplace transform representations.

5. Demonstrate understanding of properties of transforms and their use in solving systems problems.

6. Demonstrate ability to synthesize systems from transfer functions using basic op amp building blocks.

7. Demonstrate understanding of transfer functions, including frequency response and effect of pole/zero placement. Demonstrate ability to use Bode plots for frequency response.

8. Understand filtering from a spectral point of view.

ECE 3640 Signals and Systems

1. Understand the concept of a frequency domain representation of a signal and basic concepts of bandwidth.

2. Be able to compute the Fourier transform of common signals.

3. Understand system response concepts in discrete time.

4. Understand discrete-time frequency response.

5. Be aware of issues related to sampling

6. Have a basic understanding of the use of the FFT for analysis.

7. Demonstrate ability to move between time domain and frequency domain (frequency response).

8. Demonstrate understanding of signal space concepts, in particular Fourier series.

ECE 3710 Microcomputer Hardware and Software

1. Write a simple assembly-language routine for the 8088 microprocessor.

2. Build and debug a small microprocessor system which includes an 8088 microprocessor, memory, and I/O.

3. Document the hardware and software

4. Demonstrate a basic knowledge of microcomputer system concepts.

ECE 3720 Microcomputer Systems Programming

1. Describe the architectural features of the Intel microprocessors from the 8088 through the Pentium.
2. Become familiar with assembers and assembly language programming.
3. Write software applications in assembly, C, and C++ to access computer features through BIOS, DOS, and Windows.
4. Interface C and assembly language.

ECE 3820 Design I

1. Understand the process of engineering design.
2. Define and plan an engineering design project.
3. Apply systematic decision analysis to decide between feasible alternative solutions to a problem.
4. Carry out simple cost estimation and engineering economic analysis for an engineering design problem.
5. Communicate engineering information effectively to a diverse audience of engineers, managers, customers, etc., through oral presentations and written materials.
6. Identify the interdisciplinary aspects of an engineering problem.
7. Identify ethical issues related to engineering practice.

ECE 3870 Electromagnetics
At the conclusion of the course, students must be able to:

1. Demonstrate the ability to compute the following for loaded transmission lines (lossy or lossless) using either a Smith chart or classical theory.
   - Voltages and Currents in the time or frequency domain (for sinusoidal, stepped, or pulsed source)
   - Impedances on the line including input impedance
   - Standing wave ratio
   - Reflection and Transmission Coefficients
   - Power delivered to the load, drawn for the source, lost in the line
2. Design Matching networks for loaded transmission lines
   - Quarter Wave Transformers (for real or complex loads)
   - Single Stub Matching Networks
3. Rectangular metallic waveguides.
4. Radiated field from a Hertzian dipole source.
5. Compute electric and magnetic fields from plane waves incident on layered media (lossless and lossy). Incidence may be normal or oblique. This includes:
   - E and H fields or power in the time or frequency domain (for sinusoidal, stepped, or pulsed sources)
   - Characteristic Impedances in the media including input impedance
   - Standing wave ratio

- Reflection and Transmission Coefficients

ECE 4650/6650 Optics I
Students will understand:

1. Mathematics of wave motion
2. Geometrical optics: Thin lenses: lense equation; focal points; ray tracing
3. Geometrical optics: Thick lenses; matrix descriptions; edge effects
4. Electromagnetic theory of light: Fresnel integrals; boundary conditions and Maxwell's equations; normal and oblique incidence

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ECE 4680/6680 Optics II Students will understand

1. Polarization
2. Interference
3. Diffraction
4. Fourier optics
5. Coherence theory
6. The quantum nature of light.

ECE 4250 Internship/Co-op

1. Gain experience in an industrial engineering environment.
2. Gain experience in working with a team of engineers.
3. Appreciate real-world constraints in the development of projects.

ECE 4740 Computer and Data Communications

1. Students will understand the practical implications of the physical infrastructure of computer communications systems, including transmission lines and hardware interfaces, and be able to assess the effects of variations of the infrastructure upon performance.
2. Students will understand the physical requirements of Ethernet systems and the protocols used by Ethernet.
3. Students will understand the operation of TCP/IP protocols, including UDP, and IP.
4. Students will be able to implement applications accessing Service Location Protocols, Domain Name Servers, and the File Transfer Protocol.

ECE 4840 Design II

1. Demonstrated ability to define an engineering problem and identify alternate feasible solutions.
2. Demonstrated ability to successfully plan an engineering project.
3. Demonstrated ability to successfully manage an engineering project.
4. Demonstrated ability to apply systematic decision analysis to select a "best" solution to an engineering design problem.

5. Demonstrated effective oral and written skills for technical communications.

6. Demonstrated ability to apply ECE knowledge and skills to solve a significant ECE problem.

ECE 4850 Design III

1. Demonstrated ability to successfully manage an engineering project.

2. Demonstrated ability to conduct detailed performance design of system components.

3. Demonstrated effective oral and written skills for technical communication.

4. Demonstrated ability to apply ECE knowledge and skills to solve a significant ECE problem.

ECE 5230 Spacecraft Systems Engineering

1. Students will understand the time and coordinate systems used in space systems engineering.

2. Students will gain a working knowledge of orbital mechanics through mastering orbital simulation software. The software package currently in use is Satellite Tool Kit from Analytical Graphics. Students will be able to design orbit for various earth orbiting satellite missions and extract information needed in the design of spacecraft systems.

3. Students will have conceptual understanding of spacecraft propulsion, launch systems, and thermal control systems.

4. Students will have an understanding and can formulate a conceptual design for a spacecraft solar battery power system.

5. Students will have an understanding and can formulate a conceptual design for a spacecraft telemetry system.

6. Students will be able to develop rational systems engineering trades based on a broad understanding of the various systems that comprise a spacecraft.

ECE/MAE 5240 Space Systems Design
Team-based design of a spacecraft system:

1. Technical design

2. Cost aspects

3. Production scheduling

ECE/MAE 5310 Control Systems I

1. Understand how to develop differential equation models of physical systems

2. Ability to write equivalent differential equation, transfer function, and state space models for a give system.

3. Knowledge of classical control system analysis techniques, including stability, system response and performance characteristics, Routh-Hurwitz, root locus and Bode.

4. Knowledge of modern control system analysis techniques, including controllability and observability.

5. Ability to apply classical controller design methodologies, including PID control, pole placement and phase compensation.
6. Ability to apply modern controller design methodologies, including state feedback.
7. Capable of applying a systematic control system design methodology to a laboratory system.

ECE 5320 Mechatronics

1. Knowledge of sensors and transducers (thermocouple, strain gauge, piezoelectric sensors, accelerometer, tachometer, potentiometer, optical encoder)
2. Knowledge of actuators (DC motor, stepper motor, hydraulic motor, piezoelectric actuator)
3. Interfacing (op-amps, signal conditioning, AD/DA, power amplifiers, Matlab serial communication, LCD modules)
4. Sampled data systems modeling and analysis (sampling process, signal reconstruction, linear discrete time models, z-transform, discrete transfer function, discrete system stability.)
5. Hardware in the loop experimentation and rapid prototyping via Matlab RTW/Quanswer realtime toolbox.
6. Basic offline system identification techniques (Matlab system identification toolbox)
7. Digital controller design (approximate continuous design, at-sample digital design, internal model principle for digital control, repetitive control, PID relay, autotuning).
8. Capable of applying a systematic control system design methodology to a laboratory mechatronic system.

ECE 5420 Microelectronics II

1. Students are able to model and analyze the performance of discrete npn and pn BJT devices with regard to DC bias, small signal voltage and current gain, input and output impedances and power dissipation.
2. Students are able to analyze npn and pnp based BJT amplifiers using discrete components in common emitter, common base and common collector circuit configurations.
3. Students are able to model and analyze the high frequency signal transfer characteristics, including gain and input/output impedances of npn and pnp analog amplifiers.
4. Students are able to model and anlyze differential and multistage amplifiers using MOSFET and BJT discrete and integrated circuits.
5. Students are able to design and use resistorless DC bias approaches and resistorless transistor loads for integrated circuit design.
6. Students are able to model, analyze, design and test MOSFET and CMOS inverter circuits for digital logic gate configurations.

7. Students experience microelectronic circuit applications such as signal amplification, wave-shaping, feedback, filtering, buffering, AD/DA converters, digital logic processing, memory subsystems and power amplifiers.

ECE 5340 Mobile Robots

1. Mobile robot kinematics, dynamics, and control
2. Motion planning
3. Locomotion, sensing, and reasoning
4. Basic knowledge in robotic vision
5. Basic approaches in multiple robot coordination

ECE 5430/6430 CMOS Integrated Circuit Design II

1. Understand MOS device behavior and modeling.
2. Experience design, layout, and simulation of digital MOS circuits.
3. Exposure to state of the art MOS digital techniques.
4. Students will recognize that digital and analog circuit design have much in common.
5. Gain experience using state of the art tools to do design analysis.
6. Design a moderately complex circuit and be able to articulate the design process and prove that it functions properly.

ECE 5460 Digital VLSI System Design I

1. Upon completion of the course a student will know how to complete the front end design of a complex digital system implemented in an ASIC, in a team environment, and using modern CAD tools. This will include:
   - Partitioning
   - Behavioral Design
   - Functional Simulation
   - Synthesis and timing analysis
   - Verification of the synthesized design

ECE 5470 Digital VLSI System Design II

1. Upon completion of the course a student will be introduced to the back end design of a complex digital system. This will include:
   - Floor planning
   - Placement
   - Routing
   - Clock design
   - Timing-driven design

ECE 5480 Electromagnetic Compatibility

1. Understand the fundamental principles of electromagnetic compatibility (EMC) and EMC measurements.

2. Understand how regulatory requirements impact the design of electronic systems.
3. Incorporate EMC mitigation principles into the design of electronic systems.
4. Design an electronic system that meets specified requirements, while optimizing performance against cost.

ECE 5530 Digital System Design

1. Students will be able to doe hierarchical design of a simple digital system, including simulation and timing analysis, using schematic capture. The design will target discrete devices.
2. Students will be able to do a hierarchical design of a simple digital system, including synthesis, simulation, and timing analysis, using Verilog coding to create the design. The design will target a CPLD or FPGA.
3. Students will be able to do a hierarchical design of a simple ASIC core, including synthesis, simulation, and timing analysis using Verilog coding. The design will target a library of standard cells.

ECE 5630 Introduction to Digital Signal Processing

1. Demonstrated understanding of the sampling process, including the concepts of aliasing, the Nyquist rate, and quantization.
2. Demonstrated understanding of the concepts of time invariance, stability, discrete convolution and discrete correlation.
3. Demonstrated ability to perform forward and inverse z-transforms, and to use them in performing convolution and analysis of discrete-time systems, both causal and non-causal.
4. Demonstrated understanding of the Discrete-time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT), and their uses in the analysis of discrete-time systems.
5. Demonstrated understanding of common Fast Fourier Transform (FFT) algorithms.
6. Demonstrated ability to design both FIR and IIR digital filters.
7. Demonstrated understanding of multirate processing concepts such as bandpass sampling, decimation and interpolation for sample rate conversion, and oversampling converters.

ECE 5640 Real-Time Processors

1. Demonstrate understanding of the architectural features of modern DSP chips and FPGAs and the way these features are used in signal processing.
2. Demonstrate understanding of the advantages and disadvantages of different implementations for FIR, IIR, and multi-rate systems.
3. Demonstrate ability to program practical algorithms to run in real-time on a modern DSP system. Programming and debugging skills will be demonstrated in both the C language and at the assembly level.
4. Demonstrate understanding of the effects of finite word-length computation on the performance of fixed-point and floating-point implementations of systems and the FFT.

ECE 5660 Communication Systems I

1. Understand analog amplitude, phase, frequency modulation and demodulation.
2. Implement analog AM and FM modulators and demodulators using discrete-time signal processing techniques. This requires an understanding of sampling, reconstruction, up-sampling and down-sampling.
3. Understand signal space concepts with application to digital transmission and reception.
4. Know and understand the operation and purpose of elements in basic baseband and bandpass digital communication systems.
5. Compute probability of bit error in basic digital communication systems over additive white Gaussian noise channels.

ECE 5740 Concurrent Programming

1. At the conclusion of the course, students must be able to explain how deadlock, livelock, and incorrect results may arise from the uncontrolled concurrent execution of programs accessing shared resources
2. At the conclusion of the course, students must be able to detect situations that may lead to these problems in actual code.
3. At the conclusion of the course students must be able to design practical concurrent applications that are free of these problems
4. At the conclusion of the course students must be able to implement practical correct concurrent applications under the Win32 and Linux operating systems.

ECE 5750 High-Performance Microprocessor Architecture

1. At the conclusion of this course students must understand the structure and operation of modern microprocessors and be able to quantitatively analyze the performance of specific code on a specific architecture.
2. At the conclusion of this course students must be able to quantitatively design options in cache and instruction set architectures for specific applications.
3. At the conclusion of this course students must be able to write efficient low-level code for a given processor architecture.

ECE 5770 Microcomputer Interfacing

1. Work with common sensors and actuators used in industry
2. Work in teams
3. Complete a large-scale project controlled by a microcomputer

ECE 5780 Real-Time Systems

1. Understand the basics of designing and/or choosing hardware and software for simple and advanced real-time embedded systems.
2. Understand current practical issues in real-time and embedded systems.
3. Be familiar with the POSIX standard and its real-time extensions.

4. Be familiar with Ada 95, the Ada real-time systems annex, Java, and the Real-time specification for Java.

5. Understand techniques and results for theoretical analysis of real-time scheduling algorithms.

ECE 5800 Electromagnetics II

1. Develop strengthened understanding of Maxwell's equations, the constituitive relations, the continuity equation, and boundary conditions.

2. Become familiar with vector potentials and the fundamentals of radiation.

3. Learn to utilize Laplace's and Poisson's equations and related methods to solve one- and two-dimensional electrostatic problems.

4. Understand intermediate electromagnetics theorems and principles.

5. Utilize and strengthen mathematical skills for working with and solving partial differential equations.

6. Develop the theoretical and mathematical background needed to pursue more specific electromagnetic applications courses.

ECE 5810/6810 Microwave Engineering I

1. Master transmission line and waveguide theory and develop a working knowledge of circuit design using microstrip waveguides.

2. Learn fundamentals of laboratory safety, procedures for use and care of microwave instrumentation, and measurement calibration techniques.

3. Become familiar with computer-aided microwave design tools, specifically Agilent's Advanced Design System.

4. Understand impedance matching and amplifier and filter design techniques as well as the theoretical limitations of each.

ECE 5820 Microwave Engineering Laboratory

1. Measure impedance, power and frequency using a vector network analyzer, spectrum analyzer, RF signal generator, and power meter

2. Design, prototype, and test in microstrip: T-junction power divider, divide detector, single stage amplifier, and single stub matching network with quarter-wave monopole antenna.

3. Evaluate the effect of individual components in overall system performance.

4. Debug and time components as necessary

5. Connect all components into a receiver system for FSK WLAN and test it for wireless data transmission between two PCs.

ECE 5850 Antennas I

1. Properties of antennas

2. Mathematical modeling of antennas

3. Computer modeling of antennas

4. Antenna design for communications and sensing systems

5. Various antenna types

ECE 5870 Wireless Communications

1. Understand the proper use of RF laboratory equipment.
2. Understand the cellular structure.
3. Learn how to characterize large and small scale fading in the communication channel.
4. PN code generation and different spread spectrum techniques.
5. Different types of multiple access techniques in a wireless system.

ECE 6010 Stochastic Processes

1. Review set theory pertinent for the study of probability and stochastic processes; understand the idea of a probability space; know the basic axioms of probability.
2. Understand the concept of random variables and random vectors and associated functions, and be acquainted with some basic discrete and continuous random variables.
3. Understand expectations and moment generating functions.
4. Be introduced to important inequalities in probability: Markov, Chebyshev, Jensen's.
5. Understand issues related to convergence of sequences of random variables and modes of convergence.
6. Be familiar with change of variable concepts and formulas.
7. Understand definitions of random processes and functions such as mean and autocorrelation. Be familiar with stationarity concepts. Be introduced to power spectral densities.
8. Be able to compute quantities associated with random processes through linear systems (mean and autocorrelation functions)
9. Be introduced to linear MMSE filtering and see Wiener filtering.
10. Be familiar with basic concepts related to Markov chains in both discrete and continuous time, including state diagrams, probability transition matrices, steady-state probabilities, and waiting times.

ECE 6030 Mathematical Methods for Signals and Systems

1. Understand the mathematical preliminaries leading up to the proof of the projection theorem: metric spaces, vector spaces, norms, inner products, orthogonality, Hilbert and Banach spaces, projection operators, etc.
2. Learn how to recognize, set up, and solve least squares problems and dual approximation problems.
3. Understand aspects relating to linear operators: norms, adjoints, geometry of linear equations, the four fundamental subspaces, pseudoinverses, etc.
4. Understand important matrix factorizations, such as LU, Cholesky, and QR, and how to employ them in solving linear systems in general and least-squares problems in particular.

5. Understand eigenvalues and eigenvectors and Jordan forms and applications of the eigendecomposition in signal processing problems.

6. Understand the singular value decomposition and use it to solve signal processing problems.

ECE 6100 Electromagnetics Seminar — Taught on demand on special topics.

ECE 6240 Space Environment and Engineering

1. A basic understanding of the space environment including the interaction of the solar cycle, magnetosphere, ionosphere, and thermosphere. A basic understanding of geomagnetic storms and how they perturb the earth space environment.

2. A working model of space physics models including IGRF, IRI, MSIS, and radiation belt models. An understanding of the geophysical indexes upon which these models depend.

3. A working knowledge of distribution functions and fundamental length, time, and velocity scales for the space environment.

4. An understanding of the fundamental interactions of spacecraft with the neutral, vacuum, radiation, particle, and plasma environments of space.

ECE 6320 Multivariable Linear Control Systems

1. Analysis of MIMO continuous LTI systems, including realizations, solutions to the state-space equations, BIBO stability, internal stability, controllability (stabilizability), observability (constructability) and Kalman decomposition.

2. SISO state feedback design.

3. MIMO state feedback design.

4. Observer-based MIMO state feedback design.

5. Realization and coprime factorization.

6. Robust tracking and disturbance rejection.

7. Analysis and design of MIMO systems.

ECE 6330 Nonlinear and Adaptive Control

1. Phase-plane approach for characterization of 2nd order nonlinear systems.

2. Normed vector spaces (contraction mapping in particular)

3. Lyapunov direct method for nonlinear system analysis.

4. Simple model reference adaptive control and non-identifier based adaptive control (or UAS: universal adaptive stabilizer.

5. Nonautonomous nonlinear systems

6. Barbalat's lemma

7. Lyapunov's indirect method

8. Basic idea of central manifold theorem

9. Construction of Lyapunov functions: VGM, ROA

10. Other stability notions: ISS and E.S., L-stability and small gain theorem, passivity.

11. Frequency domain analysis of nonlinear systems: circle criterion/Popov criterion/PR lemma.

12. Describing function/relay PID autotuning.

13. Analysis of feedback controlled nonlinear systems

14. Feedback linearization and normal forms

15. Sliding mode control/iterative learning control.

16. Applications: adaptive friction compensation, other nonlinearities.

ECE 6340 Spacecraft Attitude Control

1. Students will understand attitude kinematics used in space systems engineering.

2. Students will understand attitude dynamics used in space systems engineering.

3. Students will develop controller designs and evaluate these designs for the major control methods used in attitude control systems, including spin stabilized, momentum bias, 3 axis zero momentum and thruster-based methods.

4. Students will be able to determine the effects of fluid slosh, structural vibration and sensor noise on the performance of attitude control systems.

5. Students will understand the fundamentals of attitude determination (e.g., Triad and Quest) plus be introduced to Kalman filtering for attitude estimation.

ECE 6350 Robotics

1. Kinematic notation

2. Forward kinematics

3. Inverse kinematics

4. Kinetic analysis

ECE 6490 Radar I After completing this course, students will be able to:

1. Understand and analyze the performance of basic subsystems in a radar system.

2. Determine and calculate the parameters associated with radar system design and performance evaluation.

3. Understand the differences between radar applications and how those differences affect system design.

4. Demonstrate a mastery of course material by developing a simulation of radar systems by designing a radar toolbox against defined criteria.

ECE Spacecraft Navigation

1. Rigid motions and homogeneous transformations

2. Forward and inverse kinematics

3. Path and trajectory planning

4. Independent joint control

5. Dynamics
6. Linear nonlinear control of manipulators
7. Cooperative robotics

ECE 6600 Computer Networking I

1. Understanding of physical and data link layer properties such as wired and wireless data transmission media, multiple access methods, error control, flow control.
2. Exploration of topics such as wireless network, PST vs. cable TV, bluetooth, IPv7 vs IPv4.
3. DHCP protocol.
4. Understanding of ARP, ICMP, UDP and TCP protocols.
5. Fundamental network programming under Linux.

ECE 6620 Digital Image Processing

1. Demonstrated understand of the basic concepts of two-dimensional signals and systems, including 2-D singularity functions, impulse response, convolution (separable and nonseparable) and BIBO stability.
2. Demonstrated understanding of 2D Fourier transform concepts, including the 2D DFT and FFT, their properties, and the computational complexities of the FFT algorithms.
3. Demonstrated ability to perform forward and inverse 2D Z-transforms, and to use them in performing convolution and analysis of 2D discrete-time systems, both causal and noncausal.
4. Demonstrated understanding of the fundamental image enhancement algorithms such as histogram modification, contrast manipulation, and edge detection.
5. Demonstrated understanding of image restoration including image filtering, inverse filtering, color image processing, deblurring, linear prediction.
6. Demonstrated ability to design both 2D FIR and IIR digital filters using some basic algorithms.
7. Demonstrated understanding of image transforms and their properties including 2D DFt, DCT, DST, Hadamard, and KL transform.
8. Demonstrated understanding of image compression algorithms such as pixel coding, differential pulse code modulation, and quantization, and also the JPEG standard.

ECE 6670 Communication Systems II

1. Understand and implement techniques for carrier synchronization and symbol timing.
2. Understand issues related to combating ISI produced by bandlimited channels. Implement channel estimators, equalizers, and sequence estimators.
3. Understand techniques such as spread spectrum and ODDM that may be used for communication over fading channels.

ECE 6750 Concurrent Systems Engineering I

1. Develop correct format CSP descriptions of concurrent applications and their specifications.
2. Verify, using appropriate tools, correctness of applications with respect to formal specifications and their freedom from deadlock and livelock.
3. Implement concurrent applications in CSP-supporting programming languages.

ECE 6760 Fault Tolerant Systems At the conclusion of ECE 6760 students should be able to:

1. Explain the basic metrics used to evaluate fault tolerant systems.
2. Explain the basic methods of implementing fault tolerant hardware and software systems.
3. Statistically analyze the fault tolerance of a given system.
4. Implement a practical fault-tolerant software package.

ECE 6780 Device Drivers

Students will understand device drivers system facilities available under Linux, including:

1. Interrupt service routines
2. System calls
3. Memory management.

ECE 6800 Graduate Seminar

1. Material related to graduate program of study (programs, deadlines, etc.)
2. Presentations by various speakers.

ECE 6830 Microwave Engineering II

1. Learn laboratory safety and procedures for care of network analyzers, spectrum analyzers, synthesizers, and power meters.
2. Understand calibration and error correction techniques for microwave measurements.
3. Learn methods for designing, fabricating and testing active and passive microwave circuits, including the use of computer-aided microwave design tools.
4. Learn principles of microwave systems design, including receiver sensitivity, nonlinear performance, and dynamic range concepts.
5. Become familiar with the fundamentals of antennas as they relate to microwave systems.
6. Gain experience designing, building, and testing a microwave transistor amplifier.
7. Learn the fundamentals of microwave bipolar- and field-effect transistors and vacuum tube devices.

ECE 7030 Detection and Estimation Theory

1. Students will understand concepts related to detection theory, including Neyman Pearson, Bayes, Pfa, Pd, and likelihood ratios.

2. Students will understand concepts related to estimation theory, including maximum likelihood estimates, Bayes estimates, bias, and minimum variance.

3. Students will understand Kalman filters.

4. Students will understand ideas related to the EM algorithm, include complete and incomplete data. Also an application, such as HMM training.

ECE 7210 Spacecraft Instrumentation

1. Physics-based methods of measurement of items of interest in space, including plasmas, ions.

2. Theory of spacecraft instrumentation applying physics-based elements

3. Engineering application of theory to design instruments

4. Data reduction techniques

ECE 7350 Intelligent Control Systems Gain essential knowledge to solve some of the systems control problems not easily solved using previously learned conventional control methods:

1. Using NN/FL (neural networks/fuzzy logic) to model the complex static/dynamic systems.

2. Using NN/FL as a tool to construct the complex nonlinear controller to better control complex dynamic systems.

3. Using evolutionary computation (EC) as a tool to perform the multi-objective (MO) design of controllers.

4. Gain hands-on experience on MATLAB toolboxes for NN and FL to solve practical control design problems. Gain hands-on experience on MO EC for controller design.

5. Get familiar with other computation intelligence techniques or soft-computation techniques or nature-inspired computational techniques for dynamic system modeling and characterization.

ECE 7360 Optimal and Robust Control

1. Understand why robust control and why optimal control in engineering practice.

2. Ability to understand H_2 and H_∞ spaces and perform H_2 and H_∞ norm computation.

3. Ability to perform balanced realization, balanced model reduction and computation and interpretation of Hankel norms.

4. Ability to analyze the performance specifications and limitations.

5. Ability to perform linear fractional transformation.

6. Ability to perform analysis via structured singular values and μ and μ-synthesis.

7. Ability to tell the tradeoff between full state feedback and observer based feedback LQR/LQG/LTR.

8. Ability to design H_∞ controller.
9. Ability to perform H_∞ loopshaping and gap metric/nu-gap metric analysis.
10. Ability in solving general optimal control problems numerically.
11. Knowledge of interval analysis, LMI/SDP, QFT, and Kharitonov's interval systems using polynomial toolbox.

ECE 7610 Computer Networking II

1. In depth understanding of Unix systems facilities to design and create robust and fast network-based servers.
2. Put the knowledge to work by creating a high performance robust web server of several different designs.
3. Advanced TCP/IP protocols
4. Routing strategies
5. Details of UNIX systems for advanced use of BSD sockets and TLI streams.

ECE 7620 Advanced Digital Image Processing

1. Understand how image perception is affected by the human visual system and how that applies to image processing.
2. Be familiar with the use of the theory and practice used in image and video compression.
3. Be familiar with the mathematics and algorithms used in image restoration systems.
4. Understand the techniques used in image segmentation.
5. Understand the mathematics and techniques used in machine vision for exploiting or creating 3D imagery.

ECE 7630 Advanced Digital Signal Processing

1. Demonstrate understanding of AR, MA, and ARMA models and how the parameters are estimated.
2. Demonstrate understanding of linear minimum mean-square error (MMSE) optimal filter design.
3. Demonstrate understanding of solutions of normal equations, including Levinson-Durbin, Schur, and LDL.
4. Demonstrate understanding of optimal lattice and lattice-ladder structures for prediction and filtering.
5. Demonstrate understanding of optimal linear least squares filter design.
6. Demonstrate understanding of least-squares computational techniques (orthogalization)
7. Demonstrate basic understanding of least-mean-square (MLS) and recursive least-square (RLS) adaptive filtering.

ECE 7610 Computer Networking II Students will understand operating system facilities to support high performance networking programs, including:

1. Sockets
2. Signals
3. Conditional variables
4. System calls
5. Threads, processes, etc.

ECE 7670 Coding Theory and Practice in Communication

1. Students will understand the role of error correction coding in modern digital communication systems.
2. Students will understand groups, rings, fields, and the coding concepts built upon them.
3. Students will be familiar with structures for encoding block and cyclic codes.
4. Students will be familiar with BCH and Reed-Solomon codes, their properties, and their encoding and decoding algorithms.
5. Students will be familiar with convolutional codes and trellis coded modulation.
6. Students will be acquainted with iteratively decoded codes such as turbo codes or LDPC codes.
7. Students will have implemented decoding and encoding algorithms for many important modern codes.

ECE 7710 Concurrent Systems Engineering II At the conclusion of 7710 students should be able to:

1. Design, verify, and implement representative discrete-time applications using CSP and a common language that supports concurrency.
2. Use Promela and SPIN to verify concurrent applications.
3. Use structural induction, data independence, and data independent induction.
4. Develop applications in KRoC.
5. Use CASPER and CSP to verify the correctness of security protocols.

ECE 7750 Distributed Control Systems

1. Seeing the big picture – introduction to digital control systems.
2. Network controlled systems.
3. Wireless sensor networks.
4. Distributed parameter systems.
5. Industrial distributed control systems and large scale systems optimization.

ECE 7760 Advanced Topics in Distributed Systems — a topics course taught on demand, with no fixed outcomes.

ECE 7770 Advanced Topics in Real-Time Systems — a topics course taught on demand, with no fixed outcomes.

ECE 7850 Antennas II Upon completion of Antennas II, the students should have an understand of and be proficient in:

1. The derivation of the radiation pattern, directivity and gain of different types of antennas, including: loops, helixes, apertures, horns, and reflectors.
2. The effect on the antenna parameters due to changes in the physical dimensions or source feed of the antenna.
3. The advantages and disadvantages of each type of antennas and their applications.
4. Phased arrays, adaptive arrays, and smart antennas.
5. Setting up and solving integral equations including method of moments.
6. The development and implementation of computer codes to model and determine the characteristics of different antennas.

ECE 7860 Computational Electromagnetics Upon completion of this course, students should have an understanding of and be proficient in:

1. Developing numerical solutions for electromagnetic radiation and scattering problems.
2. Using finite difference method and setting up the numerical solution to accurately and properly characterize the problem.
3. Using finite element method to construct a numerical solution.
4. Using method of moments to numerically solve an integral equation problem.
5. Developing the appropriate boundary conditions for a finite computational domain.
6. The stability and convergence of the numerical solution.