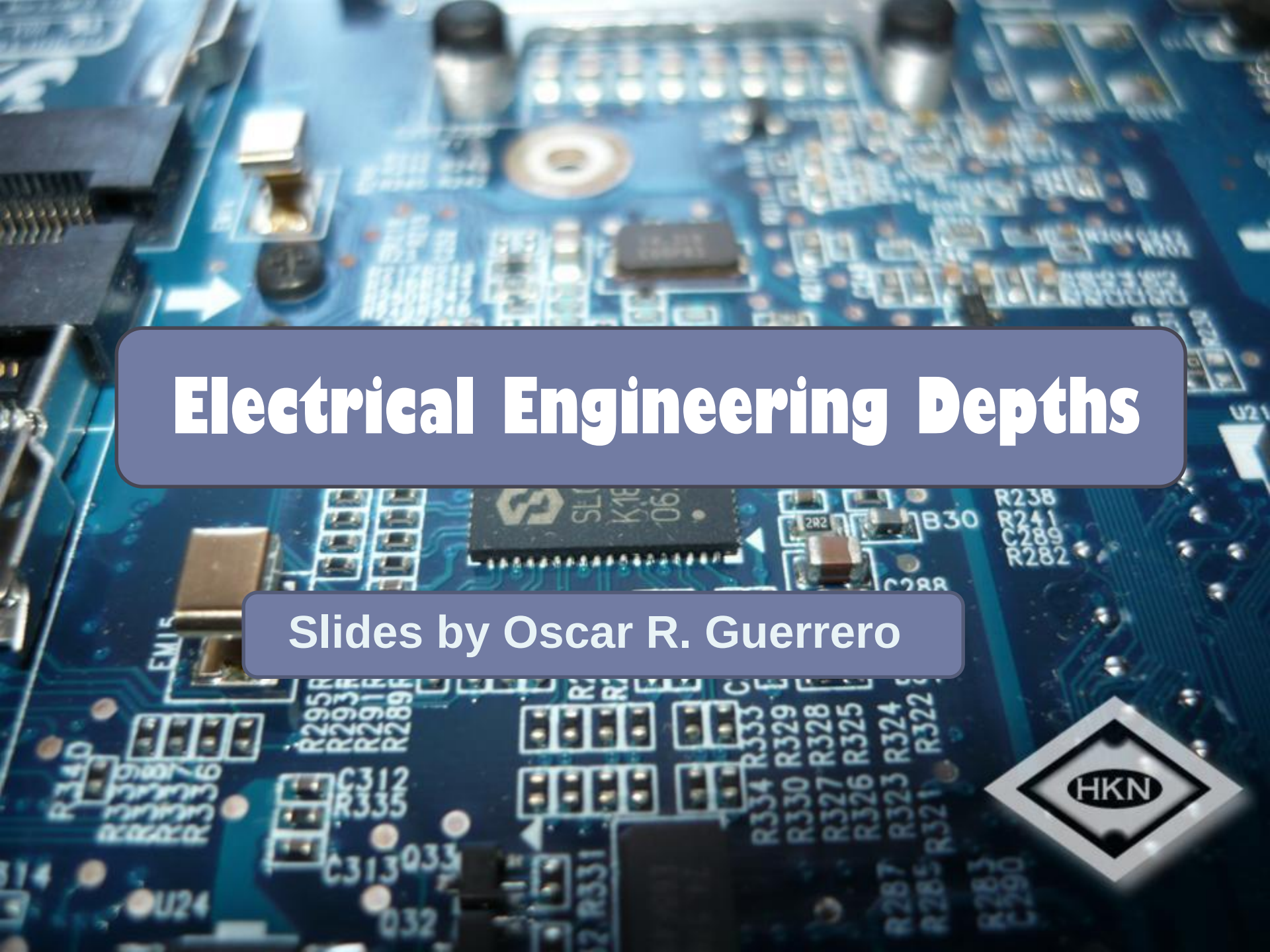

Electrical Engineering Depths
Slides by Oscar R. Guerrero
HKN

Helpful links

- Depths Sequences

http://ece.ucsd.edu/newdepths

- Class Courses

http://ece.ucsd.edu/classweb

- Course Prerequisites

http://ece.ucsd.edu/prereqs

- Course Plans

http://ece.ucsd.edu/plans

- Areas of Research

http://ece.ucsd.edu/research_areas

- Slides available at:

http://hkn.ucsd.edu/

Depths Advisors

Depth Sequence	Advisor	Email	Phone Number	Location
Devices and Materials	Vitaliy Lomakin	vlomakin@ucsd.edu	(858) 822-4726	Jacobs Hall 3201
Circuits and Systems	Bang Sup Song	bssong@ucsd.edu	(858) 822-3428	Jacobs Hall 3805
Machine Learning & Controls	David Sworder	dsworder@ucsd.edu	(858) 534-4498	Jacobs Hall 6608
Photonics	Sadik Esener	sesener@ucsd.edu	(858) 534-9997	SME Bldg 242J
Communications Systems	Kenneth Zeger	zeger@ucsd.edu	(858) 822-0440	Jacobs Hall 6605
Signal & Image Processing	Nuno Vasconcelos	nvasconcelos@ucsd.edu	(858) 534-5550	Jacobs Hall 5602

http://ece.ucsd.edu/facultyadvisors

- Staff Advisors

http://ece.ucsd.edu/ugradadvisors

-use VAC on Tritonlink

Lower Division

15. Engineering Computation (4)

Students learn the C programming language with an emphasis on high-performance numerical computation. The commonality across programming languages of control structures, data structures, and I/O is also covered. Techniques for using Matlab to graph the results of C computations are developed. ***Prerequisites:*** a familiarity with basic mathematics such as trigonometry functions and graphing is expected but this course assumes no prior programming knowledge.

25. Introduction to Digital Design (4)

This course emphasizes digital electronics. Principles introduced in lectures are used in laboratory assignments, which also serve to introduce experimental and design methods. Topics include Boolean algebra, combination and sequential logic, gates and their implementation in digital circuits. (Course material and/or program fees may apply.) ***Prerequisites:*** none.

30. Introduction to Computer Engineering (4)

The fundamentals of both the hardware and software in a computer system. Topics include: representation of information, computer organization and design, assembly and microprogramming, current technology in logic design. ***Prerequisites:*** ECE 15 and 25 with grades of C– or better.

Lower Division Continue

35. Introduction to Analog Design (4)

Fundamental circuit theory concepts, Kirchoff's voltage and current laws, Thevenin's and Norton's theorems, loop and node analysis, time-varying signals, transient first order circuits, steady-state sinusoidal response. Math 20C and Phys 2B must be taken concurrently. Program or material fee may apply. ***Prerequisites:*** Math 20A–B and Phys 2A.

45. Circuits and Systems (4)

Steady-state circuit analysis, first and second order systems, Fourier Series and Transforms, time domain analysis, convolution, transient response, Laplace Transform, and filter design. ***Prerequisites:*** ECE 35.

65. Components and Circuits Laboratory (4)

Introduction to linear and nonlinear components and circuits. Topics will include: two terminal devices, bipolar and field-effect transistors, and large and small signal analysis of diode and transistor circuits. (Program or material fee may apply.) ***Prerequisites:*** ECE 35.

Breadth Courses

100. Linear Electronic Systems (4)

Linear active circuit and system design. Topics include frequency response; use of Laplace transforms; design and stability of filters using operational amplifiers. Integrated lab and lecture involves analysis, design, simulation, and testing of circuits and systems. Program or material fee may apply. ***Prerequisites:*** ECE 45 and ECE 65. ECE 65 may be taken concurrently.

101. Linear Systems Fundamentals (4)

Complex variables. Singularities and residues. Signal and system analysis in continuous and discrete time. Fourier series and transforms. Laplace and z-transforms. Linear Time Invariant Systems. Impulse response, frequency response, and transfer functions. Poles and zeros. Stability. Convolution. Sampling. Aliasing. ***Prerequisites:*** ECE 45 with grade of C– or better.

102. Introduction to Active Circuit Design (4)

Nonlinear active circuits design. Nonlinear device models for diodes, bipolar and field-effect transistors. Linearization of device models and small-signal equivalent circuits. Circuit designs will be simulated by computer and tested in the laboratory. ***Prerequisites:*** ECE 65 and ECE 100. ECE 100 can be taken concurrently.

103. Fundamentals of Devices and Materials (4)

Introduction to semiconductor materials and devices. Semiconductor crystal structure, energy bands, doping, carrier statistics, drift and diffusion, p-n junctions, metal-semiconductor junctions. Bipolar junction transistors: current flow, amplification, switching, nonideal behavior. Metal-oxide-semiconductor structures, MOSFETs, device scaling. ***Prerequisites:*** ECE 65 and Phys 2D or Phys 4D and 4E.

Breadth Courses Continue

107. Electromagnetism (4)

Electrostatics and magnetostatics; electrodynamics; Maxwell's equations; plane waves; skin effect. Electromagnetics of transmission lines: reflection and transmission at discontinuities, Smith chart, pulse propagation, dispersion. Rectangular waveguides. Dielectric and magnetic properties of materials. Electromagnetics of circuits. ***Prerequisites:*** Phys 2A–D or 4A–E and ECE 45 with grades of C– or better.

108. Digital Circuits (4)

A transistor-level view of digital integrated circuits. CMOS combinational logic, ratioed logic, noise margins, rise and fall delays, power dissipation, transmission gates. Short channel MOS model, effects on scaling. Sequential circuits, memory and array logic circuits. Three hours of lecture, one hour of discussion, three hours of laboratory. ***Prerequisites:*** ECE 25 or CSE 140, 45, and 65 and ECE 30 or CSE 30.

No Longer Required

109. Engineering Probability and Statistics (4)

Axioms of probability, conditional probability, theorem of total probability, random variables, densities, expected values, characteristic functions, transformation of random variables, central limit theorem. Random number generation, engineering reliability, elements of estimation, random sampling, sampling distributions, tests for hypothesis. Students who completed MAE 108, Math 180A–B, Math 183, Math 186, Econ 120A, or Econ 120AH will not receive credit for ECE 109. ***Prerequisites:*** Math 20A-B-C, 20D, 20F, with grades of C– or better. ECE 101 recommended.

Communications Systems

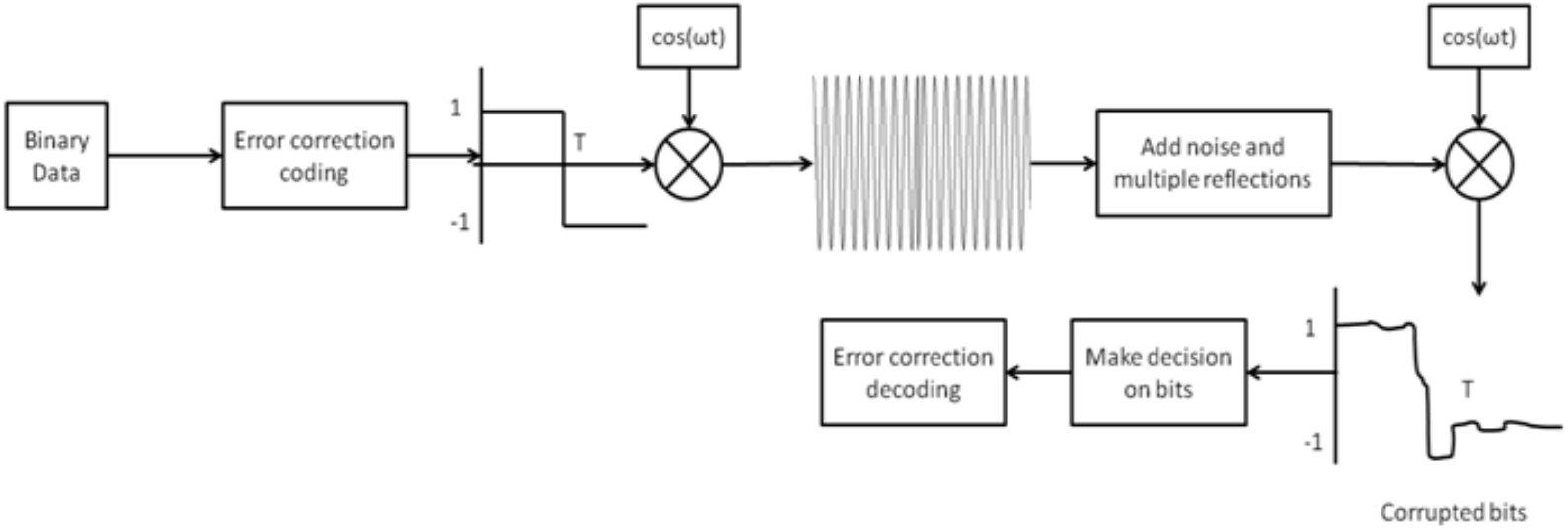
Breadth: ECE 109 & 101

-191 project software defined
-Should feel comfortable with probability
-information theory
-coding theory
-network theory

Communications Systems

- Digital wireless communication all around us
- Sending bits (0s and 1s) over the air by modulating a carrier wave
- Challenges
  - Channel impairments - noise, reflections
  - Bandwidth constraints
- Need to reduce probability of error
- We study
  - Different modulation and detection schemes for recovering bits
  - Error correcting codes once bits have been recovered

Communications Systems



Example of Binary Phase-Shift Keying (BPSK) communication system

Classes

153. Probability and Random Processes for Engineers (4)

Random processes. Stationary processes: correlation, power spectral density. Gaussian processes and linear transformation of Gaussian processes. Point processes. Random noise in linear systems. ***Prerequisites:*** ECE 109 with a grade of C– or better.

154A. Communications Systems I (4)

Study of analog modulation systems including AM, SSB, DSB, VSB, FM, and PM. Performance analysis of both coherent and noncoherent receivers, including threshold effects in FM. ***Prerequisites:*** ECE 101 and 153 with a grade of C– or better.

154B. Communications Systems II (4)

Design and performance analysis of digital modulation techniques, including probability of error results for PSK, DPSK, and FSK. Introduction to effects of intersymbol interference and fading. Detection and estimation theory, including optimal receiver design and maximum-likelihood parameter estimation. ***Prerequisites:*** ECE 154A with a grade of C– or better.

154C. Communications Systems III (4)

Introduction to information theory and coding, including entropy, average mutual information, channel capacity, block codes and convolutional codes. ***Prerequisites:*** ECE 154B with a grade of C– or better.

158A. Data Networks I (4)

Layered network architectures, data link control protocols and multiple-access systems, performance analysis. Flow control; prevention of deadlock and throughput degradation. Routing, centralized and decentralized schemes, static dynamic algorithms. Shortest path and minimum average delay algorithms. Comparisons. ***Prerequisites:*** ECE 109 with a grade of C– or better. ECE 159A recommended.

Possible Classes

- ECE 154A, B - Modulation and detection
- ECE 154C - Intro to Information theory, source and error-correction coding
- ECE 258A, B - More on modulation, detection, spread spectrum techniques
- ECE 255A,B,C - Information theory, source coding
- ECE 257A, B, C - Multi-user networks
- ECE 259A, B, C - Error correcting codes

Job Opportunities

- Cell-phone and modem companies
  - (Qualcomm, Broadcom, Cisco, Intel)
- Satellite communication

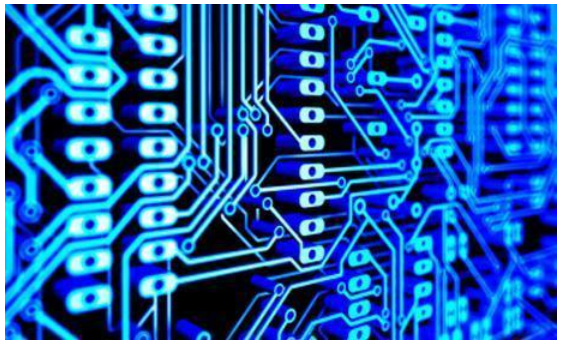
Research Areas

- Source coding for compression
- Error correcting codes
- Multiple-input multiple-output (MIMO) channels
- Multi-user networks
- Software-defined radio

Circuits and Systems

Breadth: ECE 100 & 102

-Deep level of design
-163 almost like continuation of 100
+Learn to treat systems as block diagram
+focus on the properties of circits (gain, bandwidth, noise, stability, etc.)
+Other parts deal with CMOS IC design
-164 is more analog, almost like a continuation of 102
+amplifiers, voltage refrences, current sources, etc.
-165 is more digital, similar to 108
+digital design at transistor level
-166 (microwave circuits) 161
(DSP) commonly taken with depth



Classes (minus 1)

163. Electronic Circuits and Systems (4)

Analysis and design of analog circuits and systems. Feedback systems with applications to operational amplifier circuits. Stability, sensitivity, bandwidth, compensation. Design of active filters. Switched capacitor circuits. Phase-locked loops. Analog-to-digital and digital-to-analog conversion. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 101 and 102 with grades of C– or better.

164. Analog Integrated Circuit Design (4)

Design of linear and nonlinear analog integrated circuits including operational amplifiers, voltage regulators, drivers, power stages, oscillators, and multipliers. Use of feedback and evaluation of noise performance. Parasitic effects of integrated circuit technology. Laboratory simulation and testing of circuits. ***Prerequisites:*** ECE 102 with a grade of C– or better. ECE 163 recommended.

165. Digital Integrated Circuit Design (4)

VLSI digital systems. Circuit characterization, performance estimation, and optimization. Circuits for alternative logic styles and clocking schemes. Subsystems include ALUs, memory, processor arrays, and PLAs. Techniques for gate arrays, standard cell, and custom design. Design and simulation using CAD tools. (Students who have taken CSE 143 may not take ECE 165 for credit.) ***Prerequisites:*** ECE 108 with a grade of C– or better.

166. Microwave Systems and Circuits (4)

Waves, distributed circuits, and scattering matrix methods. Passive microwave elements. Impedance matching. Detection and frequency conversion using microwave diodes. Design of transistor amplifiers including noise performance. Circuits designs will be simulated by computer and tested in the laboratory. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 102 and 107 with grades of C– or better.

Job Opportunities

Companies: Designing chips for QUALCOMM, Intel, TI, apple, etc.

Working with RF for mobile applications
-(big right now)
Need good analog and digital skills (ECE 166)
Need to have good skills with design tools
-(cadence, ADS)
Know how to use lab equipment
-(network analyzer, spectrum analyzer, oscilloscope, etc)

Research Areas

-Implementation of new circuit types
-Optimizing circuits
-Fabrications techniques
-Testing

Devices and Materials

Breadth: ECE 103

-More physics and chemistry minded

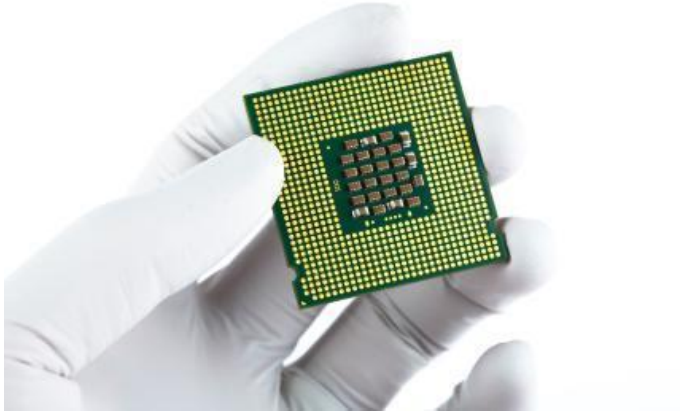
-Delve into the physics of transistors

-See the fabrication process

-Cross over with many other disciplines

+Nano and Chemical engineering

-Recommend higher education for job closer linked to subjects



Classes (minus 1)

135A. Semiconductor Physics (4)

Crystal structure and quantum theory of solids; electronic band structure; review of carrier statistics, drift and diffusion, p-n junctions; nonequilibrium carriers, imrefs, traps, recombination, etc; metal-semiconductor junctions and heterojunctions. ***Prerequisites:*** ECE 103 with a grade of C– or better.

135B. Electronic Devices (4)

Structure and operation of bipolar junction transistors, junction field-effect transistors, metal-oxide-semiconductor diodes and transistors. Analysis of dc and ac characteristics. Charge control model of dynamic behavior. ***Prerequisites:*** ECE 135A with a grade of C– or better.

136L. Microelectronics Laboratory (4)

Laboratory fabrication of diodes and field effect transistors covering photolithography, oxidation, diffusion, thin film deposition, etching and evaluation of devices. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 103.

183. Optical Electronics (4)

Quantum electronics, interaction of light and matter in atomic systems, semiconductors. Laser amplifiers and laser systems. Photodetection. Electrooptics and acoustooptics, photonic switching. Fiber optic communication systems. Labs: semiconductor lasers, semiconductor photodetectors. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 103 and 107 with grades of C– or better.

Job Opportunities

-Magnetic materials use, such as hard drive production
-Photo lithography for IC chips
-Semiconductor manufacturing
-National or scholar labs
-Computational codes for simulations and modeling

Research Areas

-CMRR (connected to industry)
-Solar cells
-Magnetic materials for memory devices
-High power gain electronics
-Electro-neural interfaces
-Flexible electronics
-New electronic material creation
-Transistor innovation

Machine Learning & Controls

Breadth: ECE 109 & Math 20F

Machine intelligence

-Artificial Intelligence / Pattern Recognition

-Situational Awareness (using sensor inputs)

-Autonomous machines and vehicles

Controls

-Algorithm focused (speed control)

-Situation interpretation and reaction

Classes (minus 2)

171A. Linear Control System Theory (4)

Stability of continuous- and discrete-time single-input/single-output linear time-invariant control systems emphasizing frequency domain methods. Transient and steady-state behavior. Stability analysis by root locus, Bode, Nyquist, and Nichols plots. Compensator design. ***Prerequisites:*** ECE 45 or MAE 140.

174. Introduction to Linear and Nonlinear Optimization with Applications (4)

The linear least squares problem, including constrained and unconstrained quadratic optimization and the relationship to the geometry of linear transformations. Introduction to nonlinear optimization. Applications to signal processing, system identification, robotics, and circuit design. Recommended preparation: ECE 100. ***Prerequisites:*** Math 20F and ECE 15 or consent of instructor.

175A. Elements of Machine Intelligence: Pattern Recognition and Machine Learning (4)

Introduction to pattern recognition and machine learning. Decision functions. Statistical pattern classifiers. Generative vs. discriminant methods for pattern classification. Feature selection. Regression. Unsupervised learning. Clustering. Applications of machine learning. ***Prerequisites:*** ECE 109 and ECE 174.

Last Class Choice (only 1)

171B. Linear Control System Theory (4)

Time-domain, state-variable formulation of the control problem for both discrete-time and continuous-time linear systems. State-space realizations from transfer function system description. Internal and input-output stability, controllability/observability, minimal realizations, and pole-placement by full-state feedback. ***Prerequisites:*** ECE 171A with a grade of C– or better.

172A. Introduction to Intelligent Systems: Robotics and Machine Intelligence (4)

This course will introduce basic concepts in machine perception. Topics covered will include edge detection, segmentation, texture analysis, image registration, and compression. ***Prerequisites:*** ECE 101 with a grade of C– or better. ECE 109 recommended.

175B. Elements of Machine Intelligence: Probabilistic Reasoning and Graphical Models (4)

Bayes' rule as a probabilistic reasoning engine; graphical models as knowledge encoders; conditional independence and D-Separation; Markov random fields; inference in graphical models; sampling methods and Markov Chain Monte Carlo (MCMC); sequential data and the Viterbi and BCJR algorithms; The Baum-Welsh algorithm for Markov Chain parameter estimation. ***Prerequisites:*** ECE 175A.

Job Opportunities

Example Companies:
Google/ Facebook/ NASA/ IBM/ Viasat/ Northrop Grumman

-Classification / Recommendation Systems
-Sensor Based interface systems
-Autonomous Systems / Drones / Robotics
-Computer Vision Systems

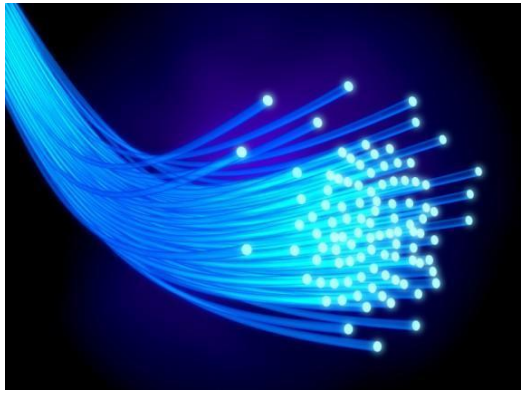
Research Areas

- Deep Learning (Neural Networks)
- Computer Vision
- Natural Language Processing
- Pattern Recognition
- Optimization

Photonics

Breadth: ECE 103 &107

- Physics of waves in the real applications
- Applications of light in systems
- Photo lithography
- Plasmonics
- Cross over with devices and material
- To get really into deep stuff have to consider grad school



Classes (minus 2)

181. Physical Optics and Fourier Optics (4)

Ray optics, wave optics, beam optics, Fourier optics, and electromagnetic optics. Ray transfer matrix, matrices of cascaded optics, numerical apertures of step and graded index fibers. Fresnel and Fraunhofer diffractions, interference of waves. Gaussian and Bessel beams, the ABCD law for transmissions through arbitrary optical systems. Spatial frequency, impulse response and transfer function of optical systems, Fourier transform and imaging properties of lenses, holography. Wave propagation in various (inhomogeneous, dispersive, anisotropic or nonlinear) media. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 103 and 107 with grades of C– or better.

182. Electromagnetic Optics, Guided-Wave, and Fiber Optics (4)

Polarization optics: crystal optics, birefringence. Guided-wave optics: modes, losses, dispersion, coupling, switching. Fiber optics: step and graded index, single and multimode operation, attenuation, dispersion, fiber optic communications. Resonator optics. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 103 and 107 with grades of C– or better.

183. Optical Electronics (4)

Quantum electronics, interaction of light and matter in atomic systems, semiconductors. Laser amplifiers and laser systems. Photodetection. Electrooptics and acoustooptics, photonic switching. Fiber optic communication systems. Labs: semiconductor lasers, semiconductor photodetectors. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 103 and 107 with grades of C– or better.

Last Class Choice (only 1)

184. Optical Information Processing and Holography (4)

(Conjoined with ECE 241AL) Labs: optical holography, photorefractive effect, spatial filtering, computer generated holography. Students enrolled in ECE 184 will receive four units of credit; students enrolled in ECE 241AL will receive two units of credit. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 182 with a grade of C– or better.

185. Lasers and Modulators (4)

(Conjoined with ECE 241BL) Labs: CO_2 laser, HeNe laser, electrooptic modulation, acoustooptic modulation, spatial light modulators. Students enrolled in ECE 185 will receive four units of credit; students enrolled in ECE 241BL will receive two units of credit. (Course material and/or program fees may apply.) ***Prerequisites:*** ECE 183 with a grade of C– or better.

Job Opportunities

Example companies: Cymer, Intel, IES Commercial

-EUV production for Lithography
-Fiber optics (information)
-Interconnect (data communication)
-Photonic Signal Transfer
-Data center (store big data)
-Bio photonics
-Plasmonics

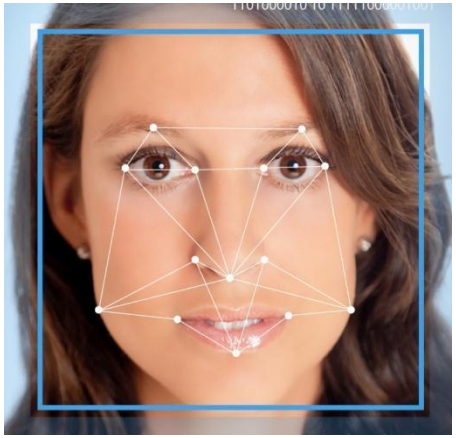
Research Areas

- Optical commutation
  - Photonic based integrated circuits
- Wave distorting materials
- Applications of lasers
- Medical Sensors and Imagining
- Crossover with many other subjects because of use in probing

Signal & Image Processing

Breadth: ECE 101 & 109

-Related to ECE 100 as well
-Closely related to machine learning
-Work with standing waves
-Deal with sensors (build systems)
  +Many times taking in images and sound
-For those who are more math orientated
-Get to clean signals and decode
  +Transforming signals (encoding)
  +Image restoration
-Statistical analysis
  (Linked to machine Learning)
-Deal with nyquest sampling



Classes (minus 1)

153. Probability and Random Processes for Engineers (4)

Random processes. Stationary processes: correlation, power spectral density. Gaussian processes and linear transformation of Gaussian processes. Point processes. Random noise in linear systems. ***Prerequisites:*** ECE 109 with a grade of C– or better.

161A. Introduction to Digital Signal Processing (4)

Review of discrete-time systems and signals, Discrete-Time Fourier Transform and its properties, the Fast Fourier Transform, design of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters, implementation of digital filters. ***Prerequisites:*** ECE 101.

161B. Digital Signal Processing I (4)

Sampling and quantization of baseband signals; A/D and D/A conversion, quantization noise, oversampling and noise shaping. Sampling of bandpass signals, undersampling downconversion, and Hilbert transforms. Coefficient quantization, roundoff noise, limit cycles and overflow oscillations. Insensitive filter structures, lattice and wave digital filters. Systems will be designed and tested with Matlab, implemented with DSP processors and tested in the laboratory. ***Prerequisites:*** ECE 161A with a grade of C– or better.

161C. Applications of Digital Signal Processing (4)

This course discusses several applications of DSP. Topics covered will include: speech analysis and coding; image and video compression and processing. A class project is required, algorithms simulated by Matlab. ***Prerequisites:*** ECE 161A.

Job Opportunities

Closely related to controls in job (mingle with each other)

-Signals are the biggest source of data
    +Many opportunities in compressing data
    +Trying to minimize bandwidth use
-Multimedia
    Audio, sound, and video compression
        -both together and separate
    Google and companies alike
        -Need media to be deciphered
            +Object recognition
    Bio medical sensors image processing

Research Areas

-Integrate active perception and machine vision
-Interactive graphical interfaces for human-machine interaction
-Wireless connectivity and remote sensing

Ex) Dr. Mohan M. Trivedi

+Creating a car with sensors to become more autonomous

-Refining algorithms used

+Emotion recognition for video and images

Helpful Tips

- Don’t stress about choosing
  - Depth does not dictate future
  - Choose what you like and try hard (it will work out in your favor)
  - If wrong one is chosen, use Technical Electives to take wanted courses
- Look up who is teaching course and reach out to them for more information about depth
  - They will have better understanding
- Check prerequisites to courses and time of year taken
  - Many courses only taught once a year and following classes require it as a prerequisites
    - **Goes for Depth course and Breathe**

Helpful Tips Continue

- Many grad students say that a masters is the best bang for your buck
  - BS/MS program geared to achieve in +1 year after BS.
  - Grad School lets you focus more on wanted subject
- Coding is a good skill to keep for industry
- **This is only meant as a primer** for you to start asking around
  - Much more information out there
  - Ask professors which teach courses
  - Try hand at internship to get true experience and help in making decision
    - real world work many times is different than academics

End of Depths

Good luck and hopefully this helps!