Choosing a Concentration & Electives

Electrical & Computer Engineering

March 2015
ECE Concentration Areas

- Signals, Communications, and Controls
  - Signals
  - Communications
  - Controls

- Electronics
  - Electronics
  - Integrated Circuits

- Nanosystems

- Applied Electromagnetics
  - Electromagnetics & Optics

- Power and Renewable Energy
  - Power
  - Renewable Energy

- Computers and Embedded Systems
BSEE Electives – 7 Concentration, 2 ECE, 1 Technical

<table>
<thead>
<tr>
<th>Sem</th>
<th>Courses</th>
<th>Concentration Electives</th>
<th>Technical Elective</th>
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<tbody>
<tr>
<td>1</td>
<td>Hist 1377, ENGI 1100, Engl 1303, ECE 1100, Math 1431, Chem 1372/1117</td>
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<tr>
<td>2</td>
<td>Hist 1378, Engl 1304, ECE 1331, Math 1432, Phys 1321/1121</td>
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<td>3</td>
<td>Pols 1336, ECE 2100, ECE 2300, Math 2433, Phys 1322/1122, Math 3321</td>
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<td>4</td>
<td>Humanities, Engl 2304, ECE 3331, ECE 3337, ECE 4436</td>
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<tr>
<td>5</td>
<td>Vis Perf Arts, ECE 3355/3155, Concentration Elec, ECE 3317, ECE Elective</td>
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<td>6</td>
<td>Pols 1337, Inde 2333, Elective Lab, Concentration Elec, ECE 2331, ECE Elective</td>
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<tr>
<td>7</td>
<td>Econ 2304, ECE 4335, Elective Lab, Concentration Elec, Concentration Elec, Technical Elective</td>
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<td>8</td>
<td>ECE 4336, Elective Lab, Concentration Elec, Concentration Elec, Concentration Elec, Elective Lab</td>
<td>14</td>
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</tbody>
</table>
BSEE Electives – 7 Concentration, 2 ECE, 1 Technical

- **CONCENTRATION ELECTIVES.** Students take seven (7) electives in their chosen Concentration in Categories 1 and 2.

- **ECE ELECTIVES.** Students must take two (2) additional ECE 3000-, 4000-, or 5000-level courses.

- **TECHNICAL ELECTIVE.** Students must take one (1) course from a list of approved non-ECE courses, OR an additional ECE Elective.

- **ELECTIVE LABS.** Students must take a minimum of four (4) 1-hour lab courses associated with their Concentration Electives, ECE Electives, and/or Technical Elective.
Concentration Areas & Electives

**Category 1: Required Courses. Students must take ALL of the courses listed in this category in their chosen Concentration Area.**

<table>
<thead>
<tr>
<th>Sig, Comm &amp; Cont</th>
<th>Electronics</th>
<th>Nanosystems</th>
<th>Applied EM</th>
<th>Power &amp; Ren En</th>
<th>Comp &amp; Embed Sys</th>
</tr>
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<tbody>
<tr>
<td>4371/4117 Intro to Telecommunication Engineering</td>
<td>3456: Analog Electronics</td>
<td>5319/5119: Intro to Nanotechnology</td>
<td>5317/5113 Microwave Engineering</td>
<td>3364: Circuits &amp; Systems</td>
<td>4437 Embedded Microcomputer Sys OR 5440 Adv Digital Design</td>
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<td>3441: Digital Logic Design</td>
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</table>
Category 2: Students must take additional courses from Category 2 in the chosen Concentration to total seven (7) courses in the Concentration.

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<tr>
<td>5318/5114 Antenna Engineering</td>
<td>5340 Intro to Well-Logging Techniques</td>
<td>5317/5113 Microwave Engineering</td>
<td>4363/4113: Electromechanical Energy Conversion</td>
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<td>5344: Signal Integrity</td>
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<td>5335/5115: State-Space Control Systems</td>
<td>5344: Signal Integrity</td>
<td>5318/5114 Antenna Engineering</td>
<td>4371/4117 Intro to Telecommunications Engineering</td>
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<td>5346: VLSI Design</td>
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<tr>
<td>5354: Digital Video</td>
<td>5346: VLSI Design</td>
<td>5322: Nanoengineering Research</td>
<td>5319/5119: Intro to Nanotechnology</td>
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<td>5354: Digital Video</td>
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<tr>
<td>5451: Internetworking</td>
<td>5358: Modern Optics &amp; Photonics</td>
<td>5356: CMOS Analog Integrated Circuits</td>
<td>5344 Signal Integrity</td>
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<td>5440 Advanced Digital Design</td>
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<td></td>
<td>5380: Power Electronics &amp; Electric Drives</td>
<td>5346: VLSI Design</td>
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<td></td>
<td>5451: Internetworking</td>
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<tr>
<td></td>
<td>5436: Advanced Microprocessor Systems</td>
<td>5358 Modern Optics &amp; Photonics</td>
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<td></td>
<td>COSC 2320: Data Structures</td>
</tr>
</tbody>
</table>
Signals, Communications and Controls
Signals

Electroencephalograph

Five EEG channels, plus respiration, blood pressure, and ECG.

Recording electroencephalogram (EEG) signal on the scalp.

Digital video camera
Signals

- **ECE 3366: Introduction to Digital Signal Processing**
  Prereq: [ECE 3337](#). Discrete-time signals and systems, discrete Fourier methods, sampling, z-transform, modulation, synthesis of discrete-time filters using digital signal processors. Examples will be taken from bioelectrical signals.

- **ECE 5354: Digital Video**
Signals

ECE 3337 Signals & Systems Analysis
ECE 3331 Programming Applications in ECE
ECE 3366 Digital Signal Processing
ECE 5354 Digital Video

Spring
Fall
Both
Uncommitted

prerequisite
CFORI

http://www.ee.uh.edu/undergraduate/future-course-offerings
Signals electives go well with controls electives. Take electives from both. These two areas have many overlapping concepts and design/analysis skills.

Signals electives allow the student to target employers that acquire and analyze seismic data (Schlumberger, Halliburton, CGC Veritas), develop medical monitoring equipment (Cyberonics, Medtronics), or design signal/video hardware components (TI).
Communications

Fiber optic communications.

Communications satellite.

Digital networking.

Fiber optic communications.
Communications

- **ECE 4371: Introduction to Telecommunications Engineering**
  Prereq: [ECE 3337](#) and [INDE 2333](#). Linear systems, filters, convolution, spectra, random processes, noise, baseband transmission, amplitude modulation and angle modulation, baseband digital communication and digital modulation.

- **ECE 5451: Principles of Internetworking**
  Prereq: credit for [ECE 3331](#) and [3441](#) and CFORI [4371](#). Local area networks, IP addressing, routing protocols, TCP flow, congestion and error control, Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP), and Network Address Translation (NAT). Selected applications.
Communications

- Job opportunities are available in companies that provide wireless/wired services (AT&T, IBM, Comcast) and build network equipment (Cisco, Lucent, Qualcomm, Broadcom, Texas Instruments). Communications expertise is needed in more specialized companies such as Schlumberger (downhole communication). Most companies need BS or MS graduates who can debug networks and ensure network security—these include oil-field monitoring companies, banks, and universities.

- ECE 4371 emphasizes the Physical Layer issues including modulation, coding, and estimation/detection.

- ECE 5451 emphasizes the Internetworking Layer and Transport Layer protocols. This course has an intense laboratory experience which prepares students to be productive in most network environments.
Controls

High-speed flight control.

Chemical plant control system.

PID loop controller.
Controls

- **ECE 4375: Automatic Control Systems**
  Prereq: ECE 3337, and CFORI 4115. Automatic Control System: mathematical modeling, block diagram, transfer function, system response, stability, root-locus, Bode analysis, Nyquist analysis, Nichols analysis, compensator design.

- **ECE 5335: State-Space Control Systems**
  Prereq: ECE 4375. State-space modeling, matrix algebra, system response, coordinate transformation, stability, controllability, observability, realization, state-feedback design and observers, nonlinear systems, Lyapunov functions, and optimal control.

- **ECE 5397: Introduction to Robotics**
  Prereq: ECE 4375. Fundamentals of robotics including rigid motions; homogeneous transformations; forward and inverse kinematics; velocity kinematics; motion planning; trajectory generation; sensing, vision; control.
Controls

- ECE 3337 Signals & Systems Analysis
- ECE 5397 Introduction to Robotics
- ECE 4375 Automatic Control Systems
- ECE 5335 State-Space Control Systems
Controls

- Applying complex-variable functions and linear algebra to carry out analysis of control systems (such as flying vehicles, power grids, chemical processes, robotics) represented by transfer functions and state-space equations.

- Employing graphical techniques (such as Root-locus plot, Bode plots, Nyquist plots) to design analog controllers (such as PID controller) to improve the performances of control systems.

- Utilizing computer control software (such as MATLAB) to develop computer-aided analysis and design techniques for improving the performances of complex control systems.
Electronics
Electronics

Instrumentation electronics.

Analog electronics.

Digital electronics.

\[ Ac = 1 \]
\[ Adiff = \frac{R2+R1}{R2} \]
Electronics

- **ECE 3456: Analog Electronics**

- **ECE 3457: Digital Electronics**
  Prereq: ECE 3355. Analysis of discrete and integrated digital electronic devices and components and their use in the design and implementation of digital circuits.

- **ECE 5344: Signal Integrity**
  Prereq: ECE 3317 and 3355 and instructor permission. Introduction to signal integrity for high-speed digital systems.
Electronics

- ECE 3355 Electronics
  - ECE 3457 Digital Electronics
  - ECE 3456 Analog Electronics
Electronics cont’d

ECE 3355 Electronics

ECE 3317 Applied EM Waves

ECE 5344 Signal Integrity
Integrated Circuits

A VLSI integrated circuit.
Integrated Circuits

- **ECE 5346: VLSI Design**
  Prereq: ECE 3456 or 3457. Integrated circuit design using computer-aided design methods; MOS, GaAs and bipolar techniques; standard cells, digital subcircuit and memory layout and design.

- **ECE 5356: CMOS Analog Integrated Circuits**
  Prereq: ECE 3456. Analysis and design of CMOS analog integrated circuits at the transistor level, single-stage and multistage amplifiers, differential pairs, current source biasing circuits, current mirrors, and operational amplifier circuit design.
Integrated Circuits

- ECE 3355 Electronics
- ECE 3457 Digital Electronics
- ECE 3456 Analog Electronics
- ECE 5346 VLSI Design
- ECE 5356 CMOS Analog Integrated Circuits

or
Integrated Circuits

- Integrated circuits (ICs) in the form of chips represent the evolution of Electronics in the current century. ICs are included in all modern devices including conventional electronics, home appliances, cars, aircraft, manufacturing equipment and military gear.

- Most large companies have IC divisions which design and sometime manufacture chips. Smaller companies use standard cells to implement electronic functions. The two major IC companies today are Texas Instruments and Intel. Other IC companies team up for research and development into consortiums such as SEMATECH.

- Opportunities exist in companies which manufacture computers, aircraft, computer software and automobiles.
Nanosystems
Nanosystems

65nm NAND Flash memory

Terabyte hard-drives (<30 nm critical dimensions)

32nm technology

Organic light emitting diode displays (use nanostructured polymers)
Nanosystems

- **ECE 5319: Introduction to Nanotechnology**
  Prereq: [ECE 3355](#), concurrent enrollment in [5119](#). Field of nanotechnology. Fundamental concepts underlying various nanotechnologies.

- **ECE 5320: Introduction to Nanomaterials Engineering**
  Prereq: [ECE 5319](#), concurrent enrollment in [5120](#). Engineering of nanomaterials with emphasis on structural, optical, photonic, magnetic and electronic materials. Synthetic methods and analytical characterization with design for applications will be emphasized.

- **ECE 5321: Design and Fabrication of Nanoscale Devices**
  Prereq: [ECE 5320](#), concurrent enrollment in [5121](#). Design and fabrication at the nanoscale. Effects of nanoscale phenomena on device scaling: technological advantages and challenges. Design, fabrication, metrology and device integration at nanoscale.
Nanosystems

ECE 3355 Electronics

ECE 5319 Introduction to Nanotechnology

ECE 5320 Introduction to Nanomaterials Engineering

ECE 5321 Design & Fabrication of Nanoscale Devices
Nanoengineering Education for UH Undergraduate Students
NanoEngineering Minor Option (NEMO)
(Fall 2009)

NanoEngineering Minor Option

Junior Yr., Fall  
Introduction to Nanotechnology (4 credits)

Junior Yr., Spring  
Introduction to Nanomaterials Engineering (4 credits)

Summer  
NEMO Research Experience (3 credits)

Senior Yr., Fall  
Design and Fabrication at Nanoscale (4 credits)

Senior Yr., Spring  
Design Project*

Objective

This program provides funding and resources for undergraduate students to acquire additional skills that will broadly prepare them for professional and scientific careers in the 21st century.

* Design project is not required to complete the Minor. While not a part of the program, special effort will be undertaken to enable nanoengineering-based design projects.
Nanosystems
Applied Electromagnetics
Applied Electromagnetics

A cell-phone base-station antenna.

A microwave integrated circuit.

A microstrip antenna array.

A microwave filter constructed from microstrip.
Applied Electromagnetics

Power buses in a substation.

A transformer in a substation.

Overhead high-voltage power lines

Large AC generators at Hoover Dam.
High-frequency EM

- **ECE 5317: Microwave Engineering**
  Prereq: [ECE 3317](#). Transmission lines, waveguides, microstrip circuits, microwave circuit theory, scattering matrices, impedance transformers, passive microwave devices, resonators, microwave tubes, and solid state active devices.

- **ECE 5318: Antenna Engineering**
  Prereq: [ECE 3317](#). Antenna concepts, linear wire antennas, linear arrays, aperture and horn antennas, printed-circuit radiators, frequency-independent antennas, and measurement techniques.
Low-frequency EM

- **ECE 2317 (3318): Applied Electricity and Magnetism**
  Prereq: ECE 1100 (1111), MATH 2433, MATH 3321, and PHYS 1322. Fundamentals of electricity and magnetism, vector calculus, Maxwell's equations, Kirchhoff's laws, static electric and magnetic fields, resistance, capacitance, inductance, magnetic circuits and transformers.
Applied Electromagnetics

ECE 3317
Applied EM Waves

ECE 5317
Microwave Engineering

ECE 5318
Antenna Engineering

ECE 2317
Applied Electricity & Magnetism
Applied Electromagnetics

- Antennas are used extensively in wireless communications, aerospace, and defense (military) areas. Antenna engineers will usually work in one of these areas. ECE 5318 provides a good background for those wishing to go into this area, or for those who simply want to know more about antennas (which are often a part of many sensor and communication systems).

- The microwave field focuses on the design of microwave circuits and devices. These include active devices such as oscillators, amplifiers, mixers, frequency converters, etc., as well as passive components such as filters and multiplexers. Microwave engineers work in a wide variety of companies, since much of the modern electronic equipment that we have operates at microwave frequencies. ECE 5317 provides a good introduction to this area.
Applied Electromagnetics

- Low frequency electromagnetics is used in a variety of areas such as power engineering and nanoengineering. Examples include:
  - Calculating the fields from power lines
  - Designing motors, transformers, etc.
  - Analyzing and designing nanomagnetic devices

ECE 2317 provides an introduction to low-frequency electromagnetics, covering basic electrostatic and magnetostatic principles.

ECE 2317 also provides a good foundation for all other EM courses, though it is not required for them.
Optics

- Lens.
- Fiber optics.
- Lasers.
- Optical reflection and refraction.
Optics

- **ECE 5358: Modern Optics and Photonics**
  Prereq: [ECE 3317](#). Lightwave fundamentals: geometrical and wave optics, interference, diffraction, scattering, Fourier optics; photonic passive & active devices: waveguides, lasers detectors, modulators, photonic integrated circuits, displays; optical system design and engineering.
Power & Renewable Energy
Power

Power transmission and distribution.

Power electronics.

Motors and generators
Power

- **ECE 4363: Electromechanical Energy Conversion**
  Prereq: ECE 3364 and CFORI 4113. Electromechanical energy conversion principles, transformers, rotating machines, and solid-state motor control.

- **ECE 5377: Power Transmission and Distribution**
  Prereq: ECE 3364 and CFORI 5127. Power transmission and distribution network architecture and composition; load curves; symmetrical components; parameters and equivalent circuits in symmetrical components for overhead and underground lines, transformers, generators and loads; sub-stations; industrial networks; network steady-state analysis; faults; protection systems; switching equipment; voltage and power static control; surge voltages and protection. A term project will be required.

- **ECE 5380 and Lab: Power Electronics and Electric Drives**
  Prereq: ECE 3355. Power electronics; power semiconductor switches; converters and inverters; DC, induction and synchronous motor drives; industrial applications; harmonics and filtering.
In each of these power courses there is a project related to topics covered in the lectures, and at the end of the semester there is a field trip to see the actual industrial equipment and installations.

ECE 4363 is a basic course for an electrical engineer. The knowledge covered is required for power-related jobs with electric utilities, electric transportation, and other industries.

ECE 5377 covers knowledge needed mainly for electric utilities, industry, commercial and residential areas.

ECE 5380 topics are applied on each of the areas where advanced power electronics, power supplies and control are needed, with electric utilities and industry.
Renewable Energy

- **ECE 5388 (5397 in Fall 2014): Renewable Energy Technology**
  Prereq: [ECE 3364](#). Introduction and comprehensive overview of renewable energy technology. Topics include distributed generation and renewable energy including wind power, solar power, fuel cells and hydropower.

- **ECE 53xx (5397 in Spring 2015): Smart Grid Technology**
  Prereq: [ECE 3364](#). Details to be determined.
Renewable Energy

ECE 3364
Circuits & Systems

ECE 5388
Renewable Energy Technology

ECE 5397
Smart Grid Technology
Computers &
Embedded Systems
Computers & Embedded Systems

Laptop computer.

Well-logging tool.

Automobile with multiple embedded systems.

Robonaut.
Computers & Embedded Systems

- **ECE 4437: Embedded Microcomputer Systems**
  Prereq: ECE 3355 and 4436. Hardware and software components of real-time embedded microcomputer systems. Programming and interfacing to real-time external devices.

- **ECE 5436: Advanced Microprocessor Systems**
  Prereq: ECE 4436. Microcomputer assembly language programming, I/O programming, I/O interface design, memory interfacing.

- **ECE 5440: Advanced Digital Design**
  Prereq: ECE 3441, 3355 and CFORI 4436. Design fundamentals and techniques using application specific integrated circuit development and synthesis tools and field programmable gate arrays. Design of control units, arithmetic and logic units, memory and I/O subsystems and cache.
Computers & Embedded Systems

- ECE 3355 Electronics
- ECE 4436 Microprocessor Systems
- ECE 3441 Digital Logic Design
- ECE 4437 Embedded Microcomputer Systems
- ECE 5436 Advanced Microprocessor Systems
- ECE 5440 Advanced Digital Design
Job opportunities are available both in companies that build computers and in companies that build systems based on digital technology.

Computer companies such as HP locally and others in Silicon Valley have hired UH graduates to work in the design of their desktop computers. ECE 5436 and 5440 are good background for that work.

Embedded systems skills are needed in industries in energy exploration (well-loggining tools), biomedical instrumentation, NASA-related design (Robonaut), telecommunications, and many others. ECE 4437 and 5440 are good preparation for work in those areas.