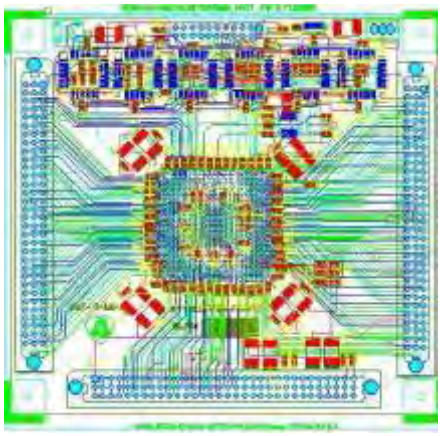
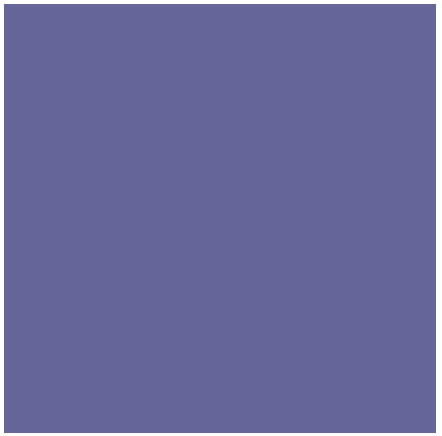
Choosing a Concentration & Electives

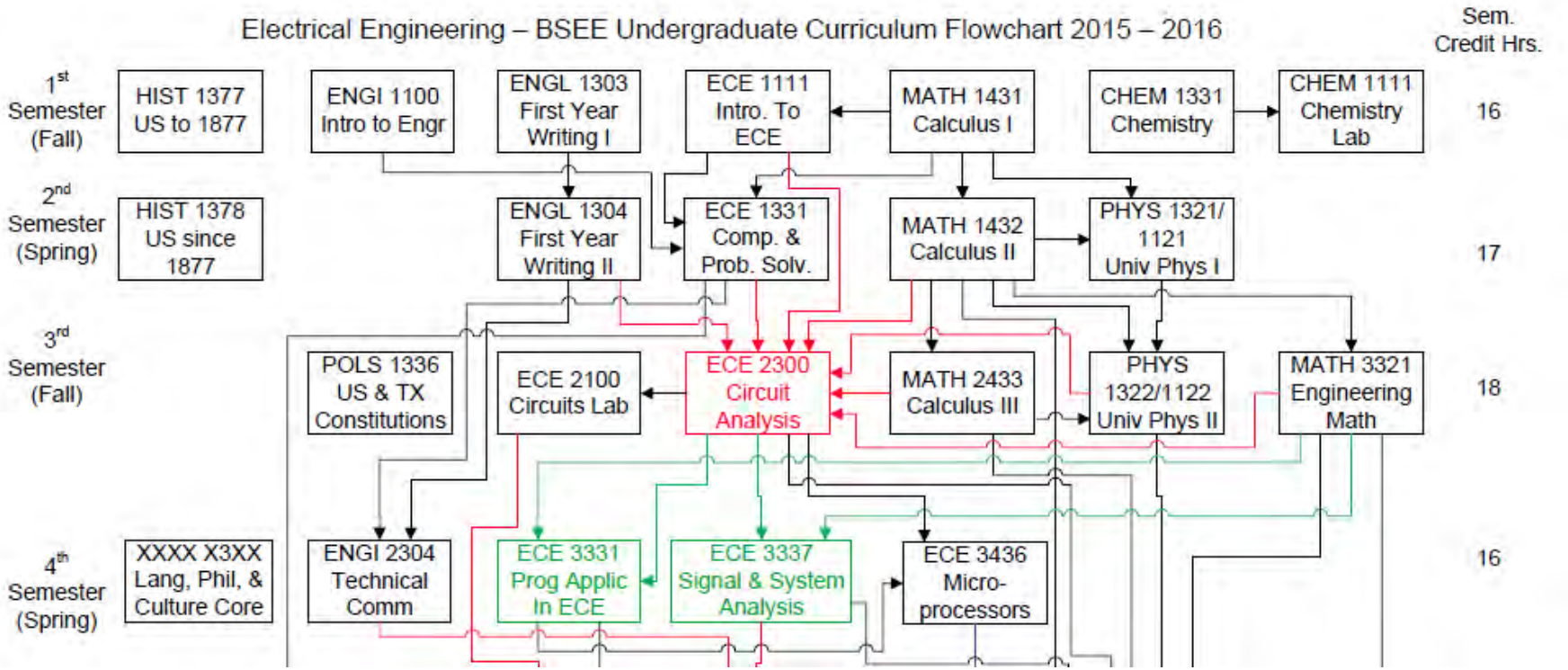




Electrical & Computer Engineering

October 2018

BSEE and BSCpE Base



UNIVERSITY of HOUSTON | ENGINEERING

Department of Electrical & Computer Engineering

Degree Plan for Electrical Engineering (BSEE)

LAST NAME: _____ FIRST NAME: _____ STUDENT ID # _____ Catalog Year _____

**Degree plan will not be processed without declared degree catalog year

Approved by Advisor: _____(sign)_____(print) Date: _____

STEP ONE: Choose Concentration Area

Students must take all courses in Category 1.

STEP TWO: Select courses

Students must take 7 concentration electives, 2 ECE electives, and 1 technical elective. Course selections must include a minimum of 4 labs. Students with 7 or more labs can substitute 3 labs for one ECE elective. *If this is your plan, list the 3 extra labs in one of the ECE elective boxes.*

STEP THREE: Get approved by concentration advisor

Students must have this formed signed by their concentration advisor before submission. Submit to the ECE front office located in N308, Engineering Bldg. 1.

CATERGORY 1: CONCENTRATION AREAS & REQUIRED CONCENTRATION ELECTIVES

Students must take **ALL** of the courses listed in this category in their chosen Concentration Area.

☐ Signals, Communications & Controls	☐ Electronics	☐ Nanosystems	☐ Applied Electromagnetics	☐ Power & Renewable Energy	☐ Computers & Embedded Systems
3366: Intro to DSP	3364: Circuits & Systems	4339/4119: Physical Principles of Solid State Devices	3318: Applied Electricity & Magnetism	3318: Applied Electricity & Magnetism	3441: Digital Logic Design
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	4339/4119: Physical Principles of Solid State Devices	5321/5121: Design & Fabrication of Nanoscale Devices		5377/5127: Power Transmission & Distribution	COSC 1430: Intro to Programming
	3441: Digital Logic Design				

CATEGORY 2: CONCENTRATION ELECTIVES

Students are free to choose from the following courses to complete (7) Concentration Electives in total.

Signals, Communications & Controls	Electronics	Nanosystems	Applied Electromagnetics	Power & Renewable Energy	Computers & Embedded Systems
Select 4	*Select 2*	*Select 3*	*Select 4*	*Select 3*	*Select 3*
☐ 3364: Circuits & Systems	☐ 2317: Applied Electricity & Magnetism	☐ 2317: Applied Electricity & Magnetism	☐ 3364: Circuits & Systems	☐ 4375/4115: Automatic Control Systems	☐ 3366: Intro to DSP
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☐ 5440 Advanced Digital Design	☐ 5356: CMOS Analog Integrated Circuits	☐ 5346: VLSI Design	☐ 5340 Intro to Well-Logging Techniques		☐ 5354: Digital Video
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☐ 5397: Introduction to Robotics		☐ 5436: Advanced Microprocessor Systems	☐ 5358 Modern Optics & Photonics		☐ 5451: Internetworking
					☐ 5397: Introduction to Robotics

ECE ELECTIVES

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

ECE ELECTIVE	ECE ELECTIVE

TECHNICAL ELECTIVE

Students must take one of the following courses.

☐ ECE _____ Any ECE 3000-, 4000-, or 5000-level course	☐ ENGI 2334 Intro to Thermodynamics	☐ MATH 3364 Complex Analysis	☐ MATH 4364 Numerical Analysis
☐ PHYS 3312 Modern Optics	☐ PHYS 3315 Modern Physics I	☐ MATH 3335 Vector Analysis	☐ MECE 3400 Intro to Mechanics

ELECTIVE LABS

Your elective choices must include at least **four** labs. Please list these here.

ECE LAB	ECE LAB
ECE LAB	ECE LAB

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.

EE Concentration Areas and Advisors

- Signals, Communications, and Controls Dr. Bhavin Sheth
  - Signals
  - Communications
  - Controls
- Electronics Dr. Len Trombetta
  - Electronics
  - Integrated Circuits
- Nanosystems Dr. Stanko Brankovic
- Applied Electromagnetics Dr. David Jackson
  - Electromagnetics & Optics
- Power and Renewable Energy Dr. Kaushik Rajashekara
  - Power
  - Renewable Energy
- Computers and Embedded Systems Dr. Yuhua Chen

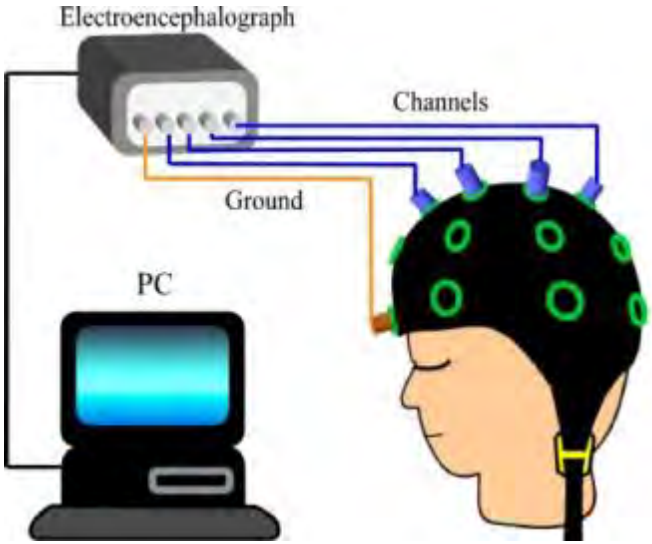
CpE Program

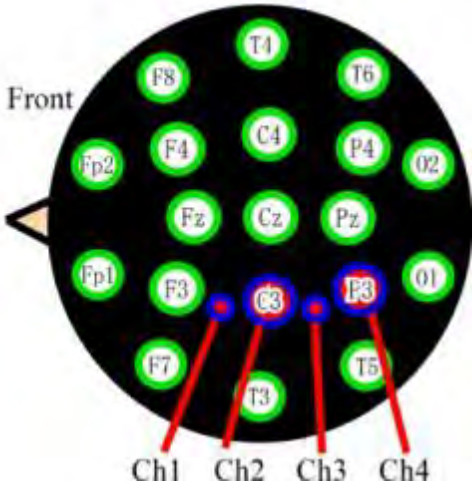
- Dr. Yuhua Chen

Signals, Communications and Controls

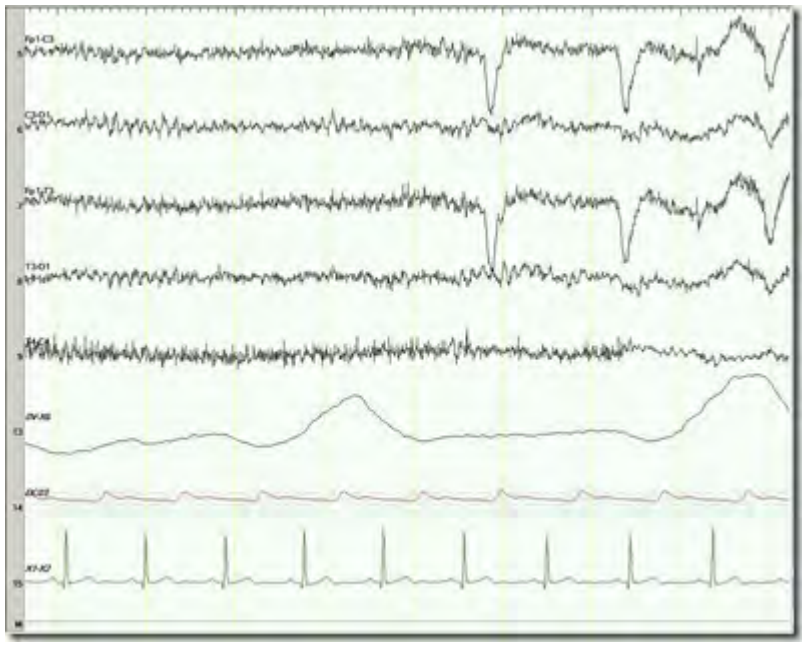
Signals

Recording electroencephalogram (EEG) signal on the scalp.





Digital video camera



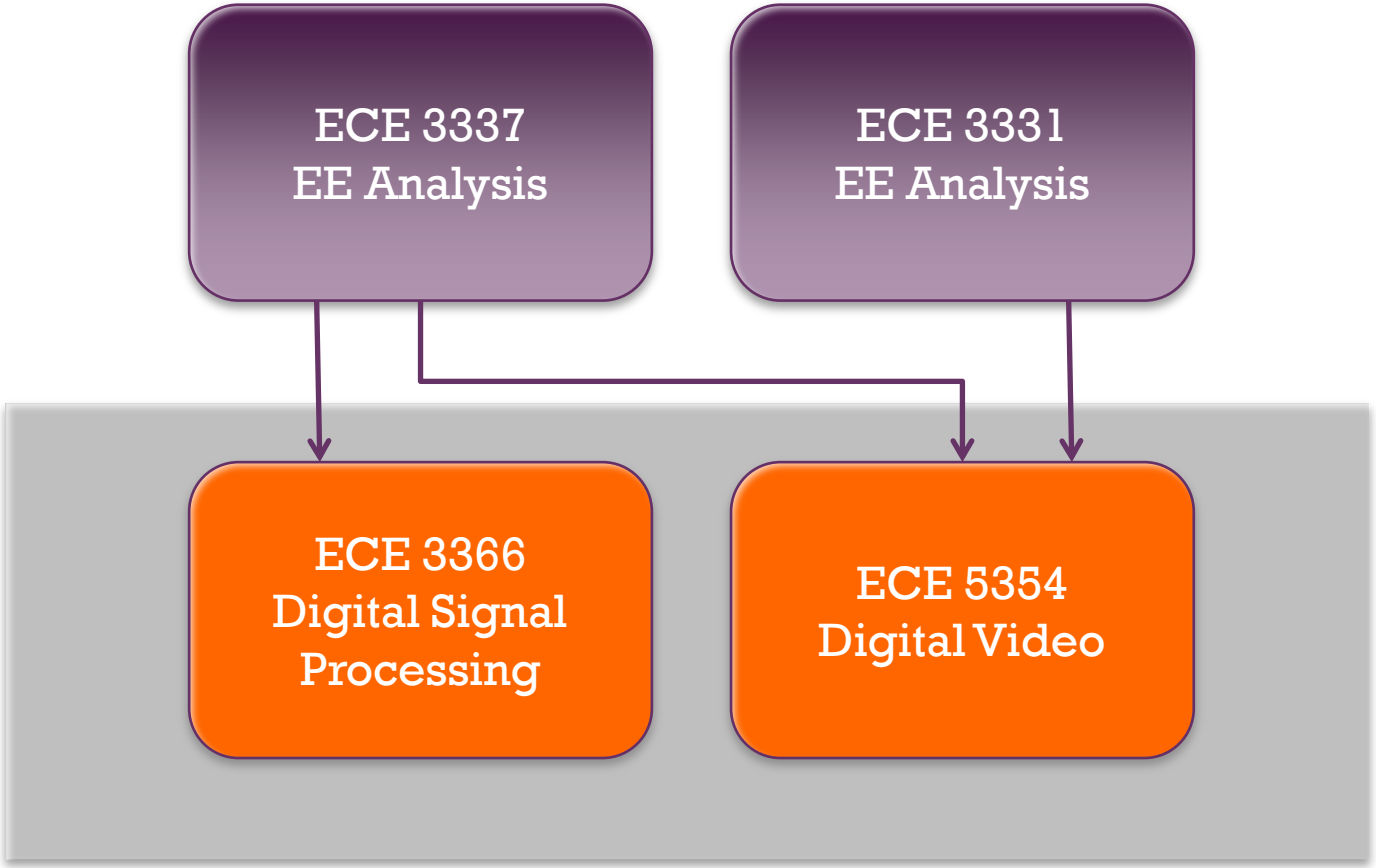
Five EEG channels, plus respiration, blood pressure, and ECG.

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**
  Prereq: ECE 3337 and CFORI 4436. Concepts, theory, and applications of digital video compression. Sampling and quantization, data compression, adaptive coding, BMP and JPEG image standards, H.261 video-conferencing, MPEG codecs, mathematical animation techniques.

Signals



Spring | Fall | Both | Uncommitted

prerequisite →

CFORI -->

http://www.ee.uh.edu/undergraduate/future-course-offerings

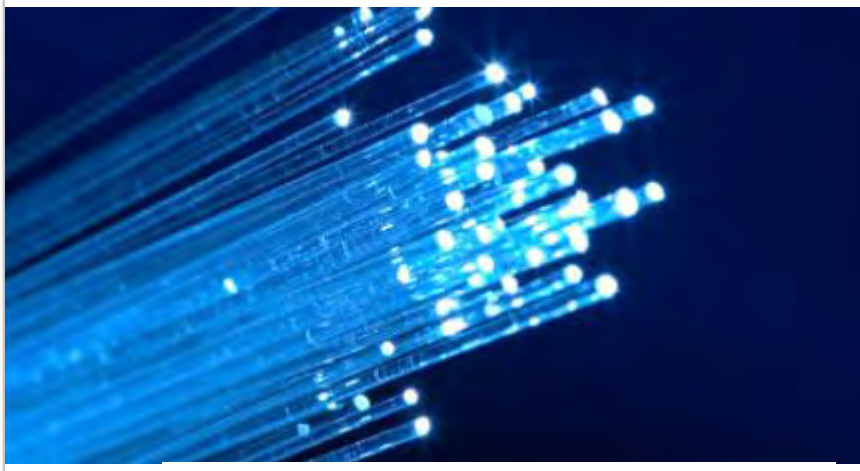
Signals

- 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

Communications satellite.

Digital networking.



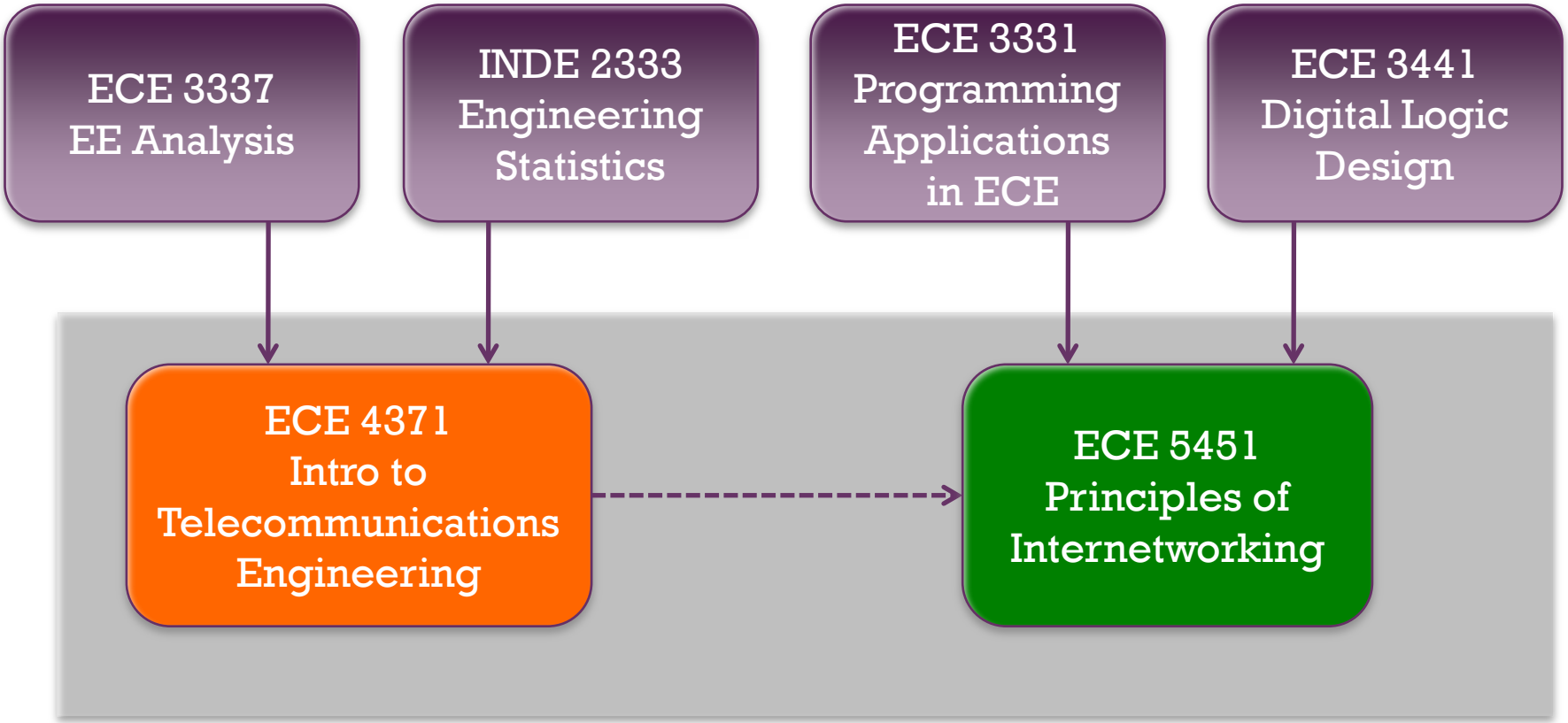
Fiber optic communications.

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

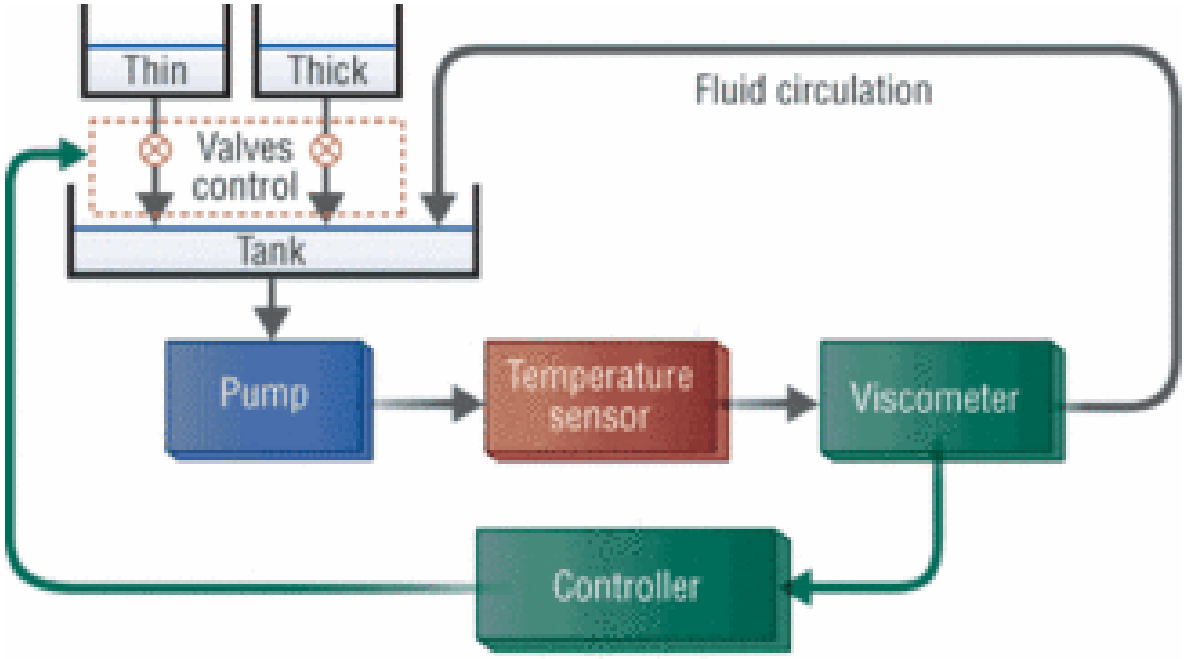


Communications

- 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.

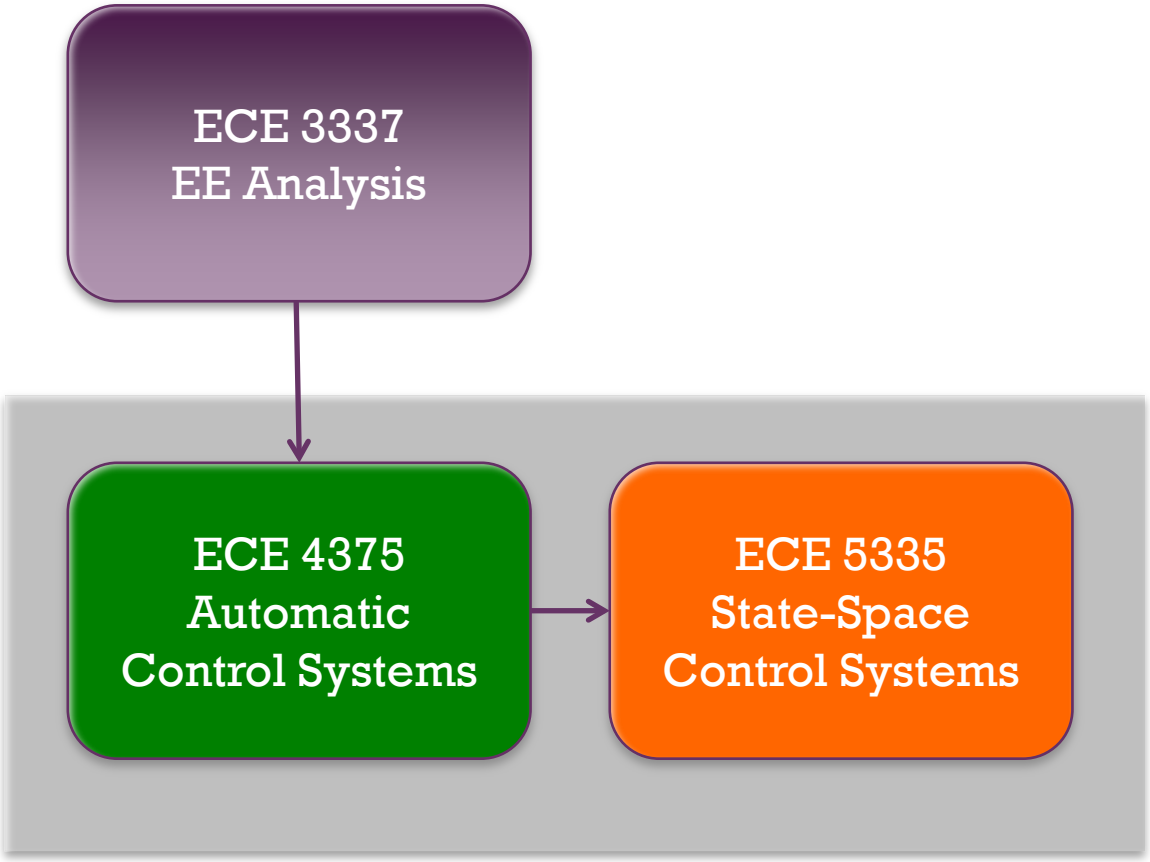
PID loop controller.

Controls

- **ECE 4375: Automatic Control Systems**
  Prereq: ECE 2300, 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.

Controls


ECE 3337
EE Analysis
ECE 4375
Automatic
Control Systems
ECE 5335
State-Space
Control Systems

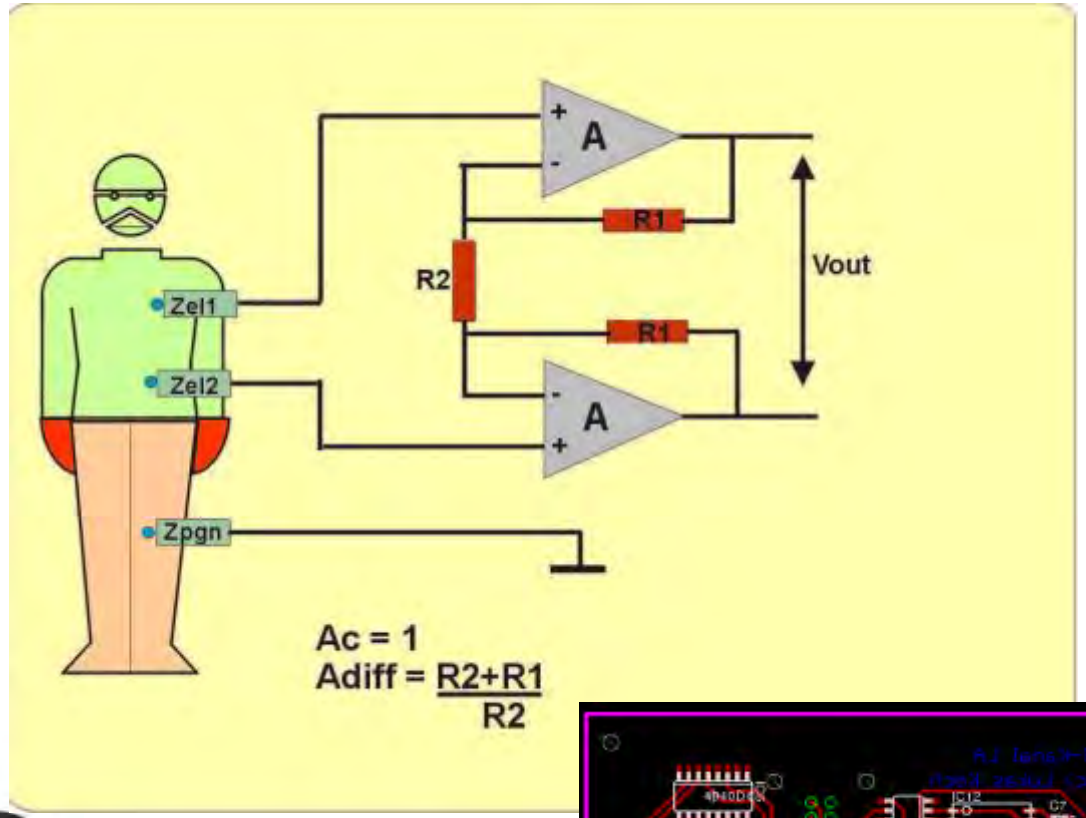
Controls

- 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.

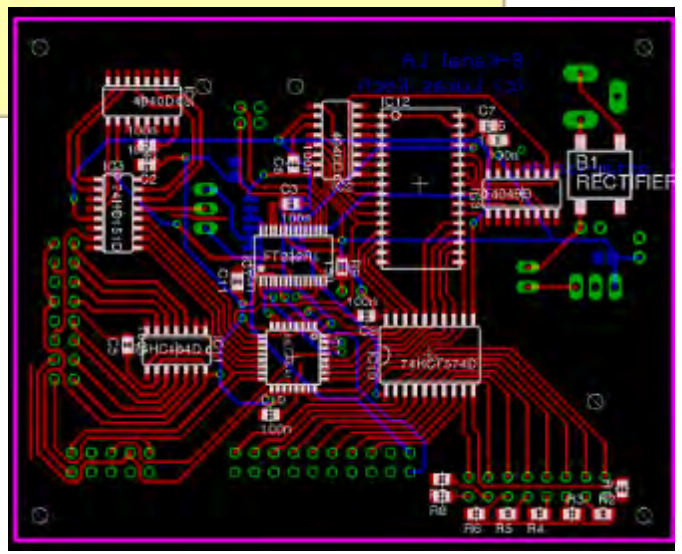
Electronics

Electronics

Instrumentation electronics.



Analog electronics.



Digital electronics.

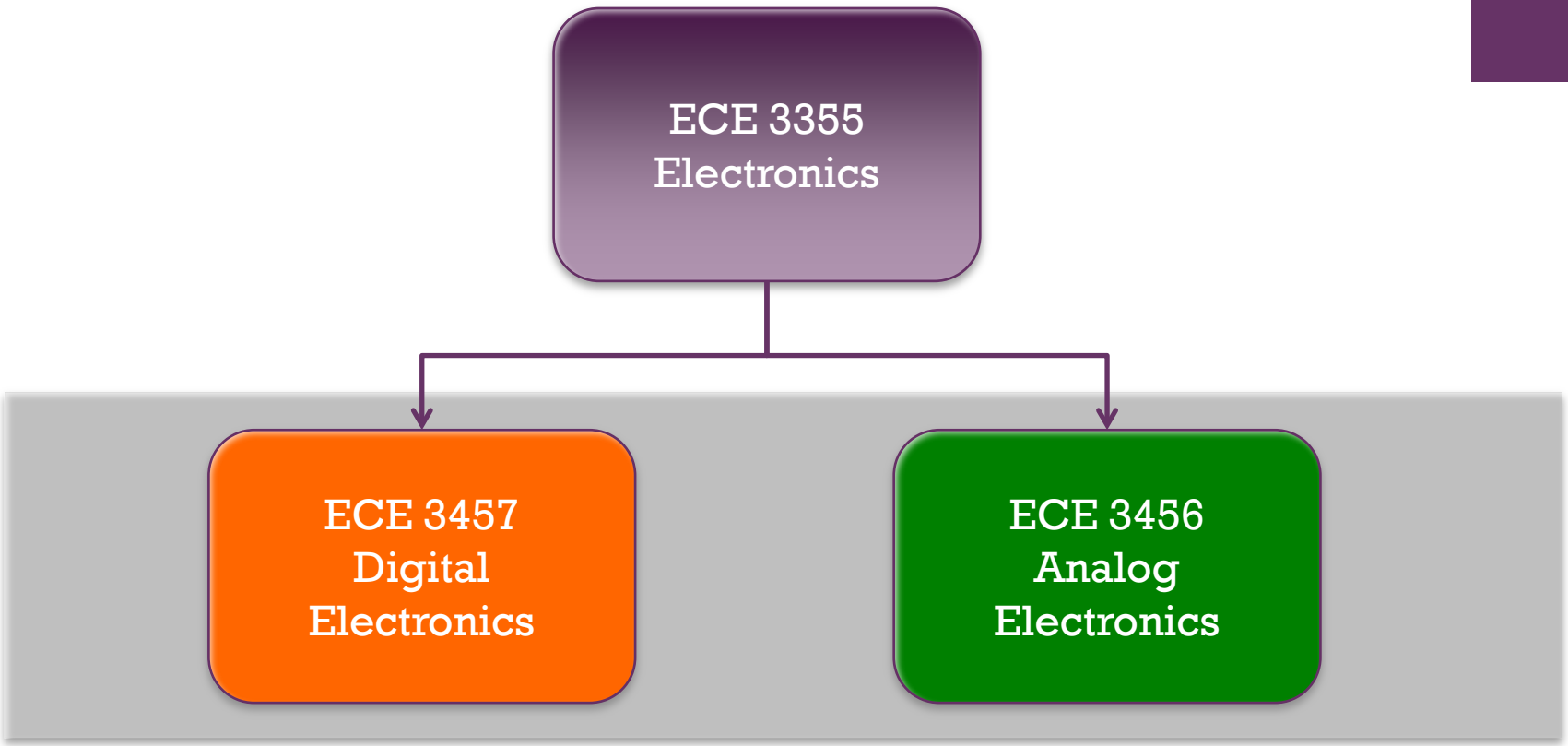
Electronics

- **ECE 3456: Analog Electronics**
  Prereq: ECE 3337 and 3355. Bipolar transistors. Multistage amplifier design. Frequency response and feedback concepts. Analysis and design using discrete and integrated devices.

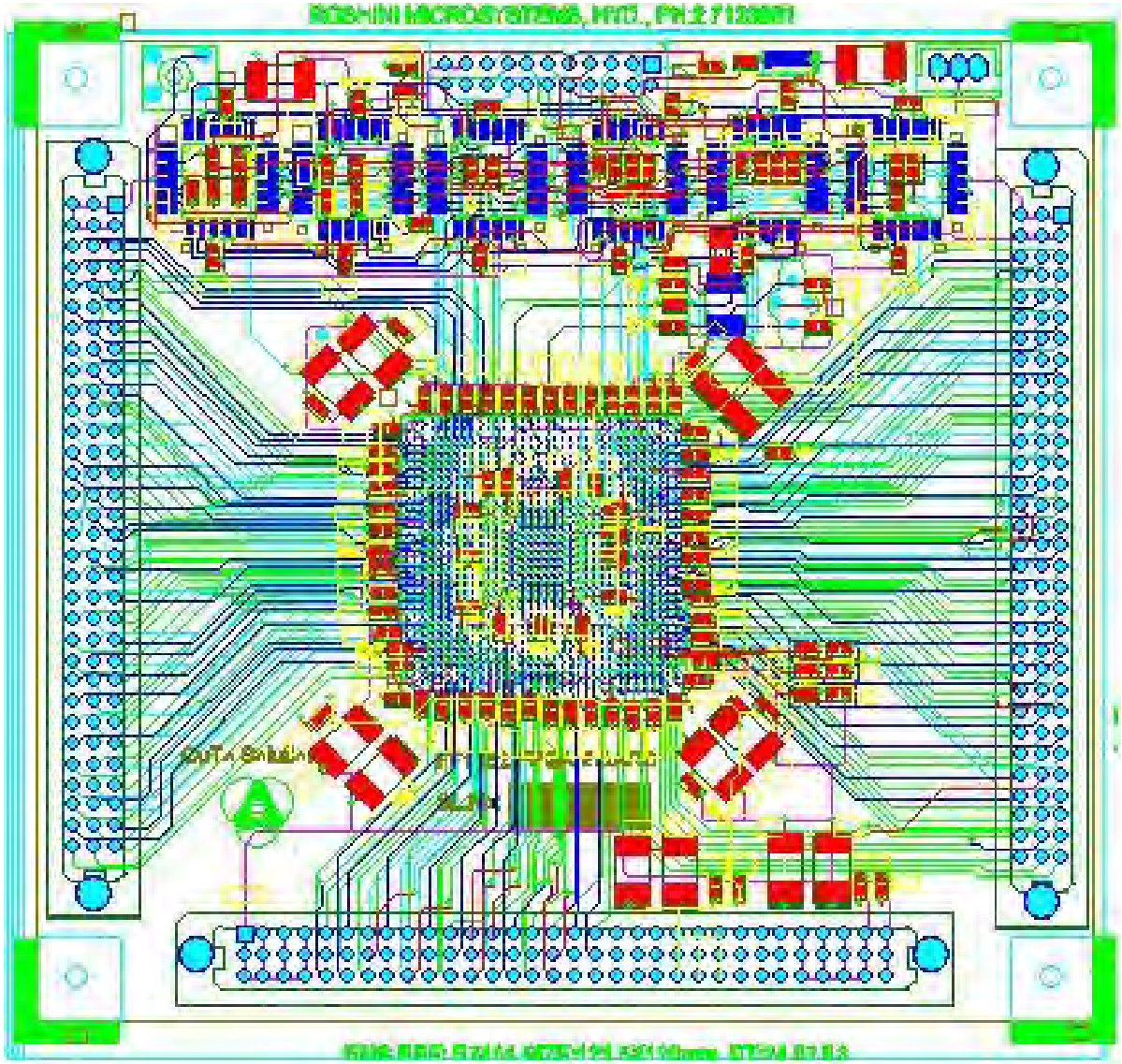
- **ECE 3457: Digital Electronics**
  Prereq: ECE 3337 and 3355. Analysis of discrete and integrated digital electronic devices and components and their use in the design and implementation of digital circuits.

- **ECE 4458: Instrumentation Electronics**
  Prereq: ECE 3337 and 3355. BJT review; FETs; differential amplifiers; op amp non-ideal characteristics; measurements with low signal-to-noise ratio and high source impedance such as bioelectrical signals; electrical safety; electrodes, transducers.

Electronics



Integrated Circuits



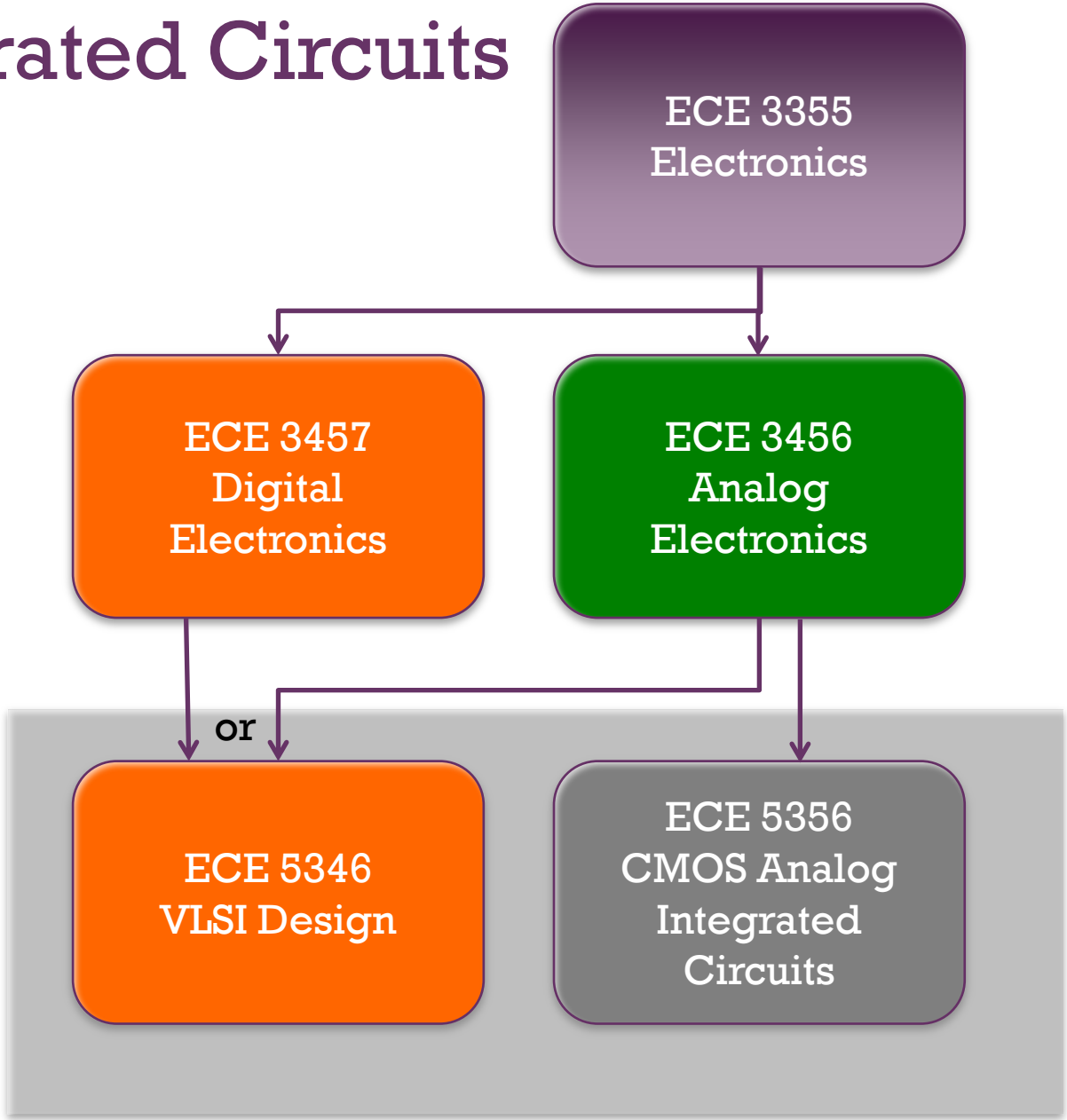
A VLSI integrated circuit.

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



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

32nm technology

Terabyte hard-drives (<30 nm critical dimensions)

Organic light emitting diode displays (use nanostructured polymers)

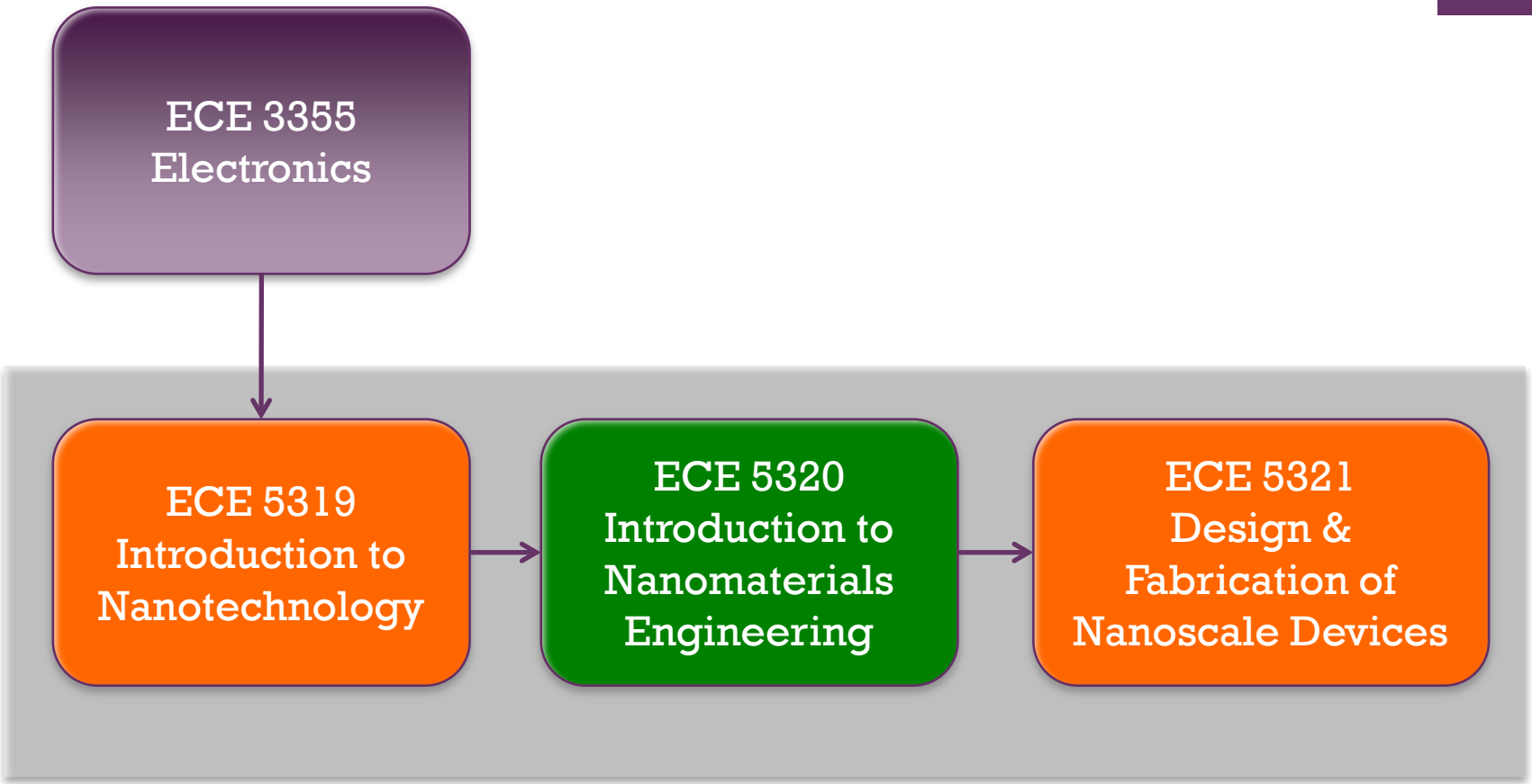
Nanosystems

- **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.

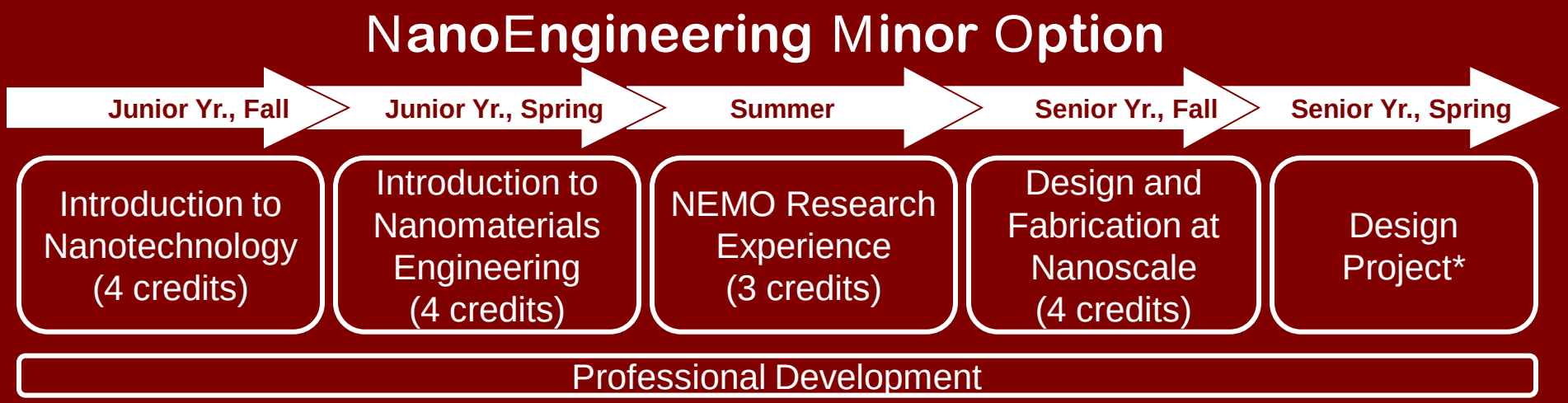
- **ECE 5321: Design and Fabrication of Nanoscale Devices**
  Prereq: ECE 5320, concurrent enrollment in 5121. Design and fabrication at the nanoscale. Effects of nanoscale phenomena on device scaling: technological advantages and challenges. Design, fabrication, metrology and device integration at nanoscale.

Nanosystems



http://www.egr.uh.edu/nemo/

Nanoengineering Education for UH Undergraduate Students
NanoEngineering Minor Option (NEMO)
(Fall 2009)

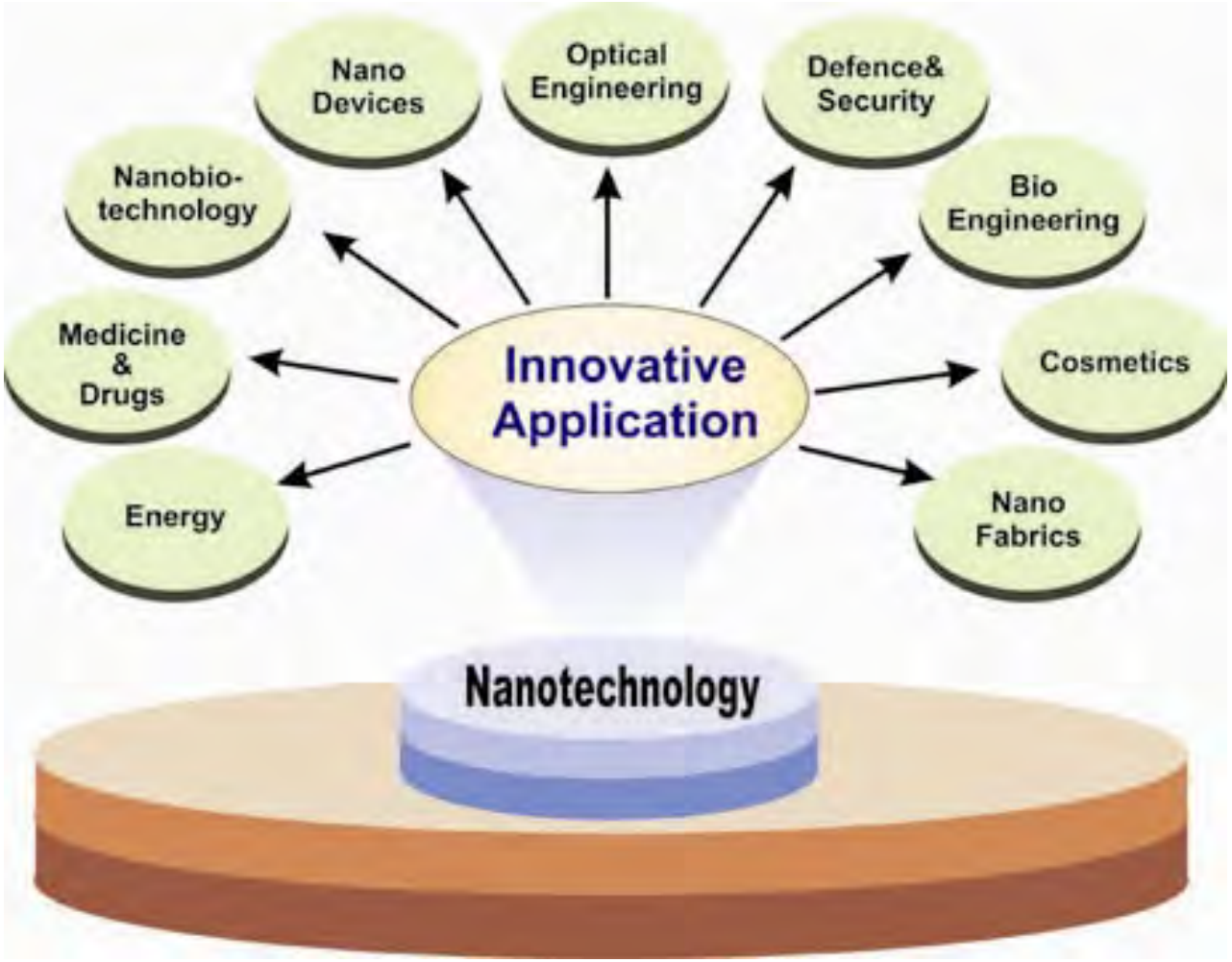


Objective

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



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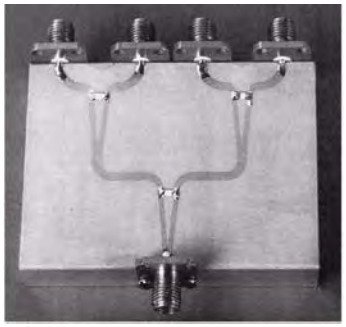
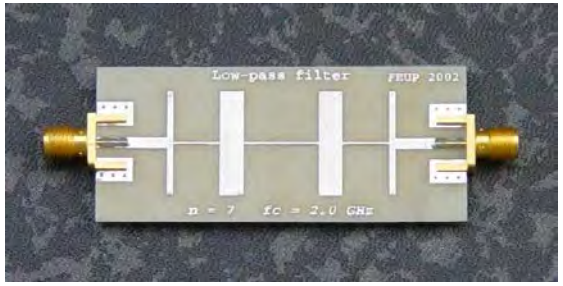
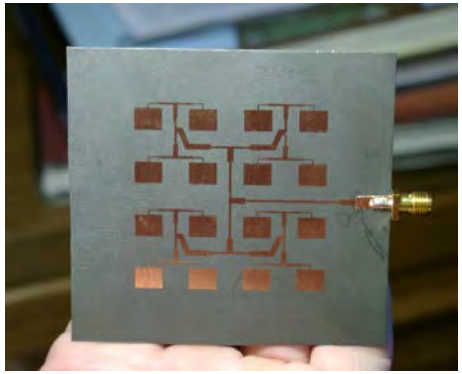
Applied Electromagnetics

EM Concentration Area

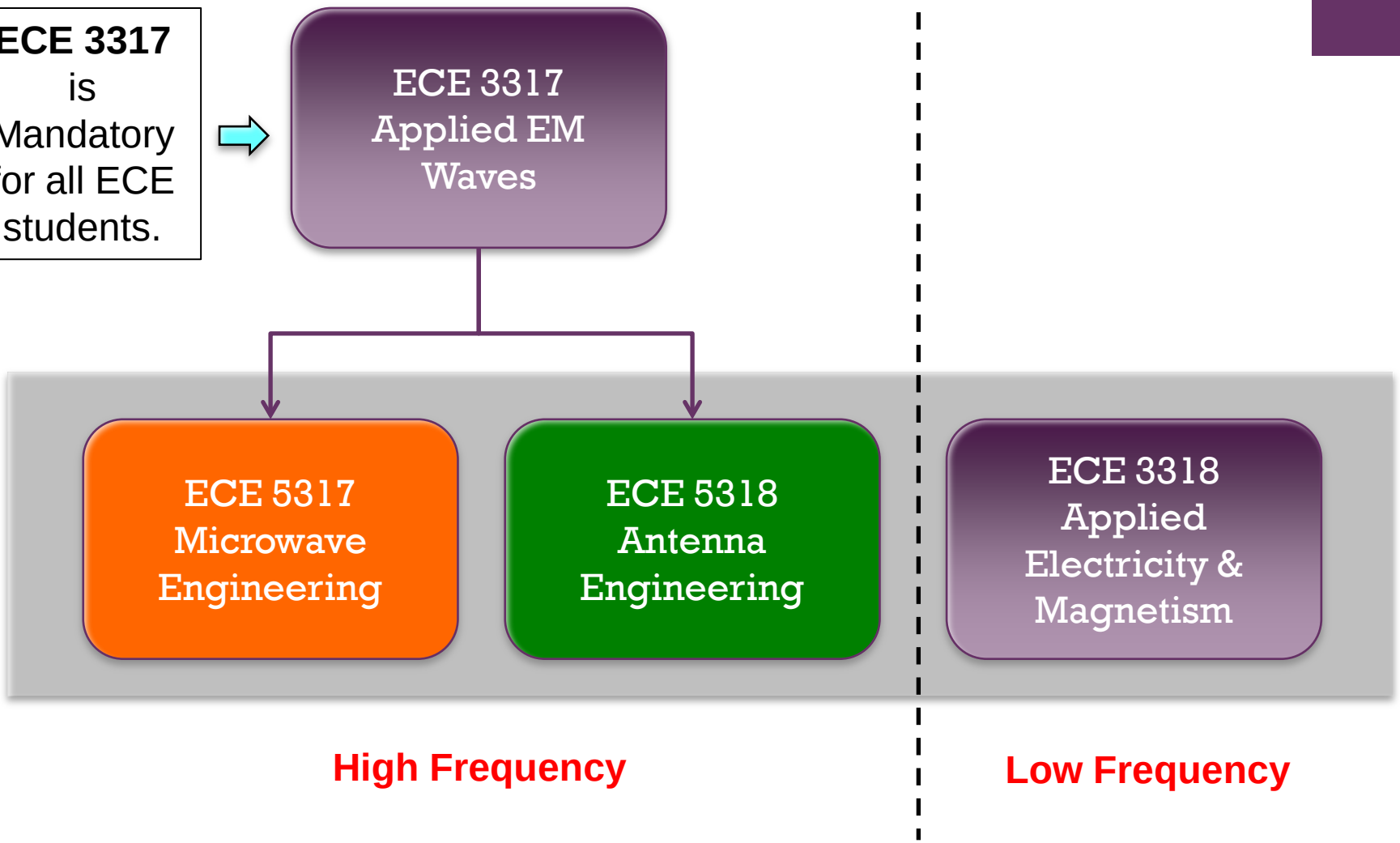






Applied Electromagnetics

ECE 3317 is Mandatory for all ECE students.



UNIVERSITY of HOUSTON | ENGINEERING

Department of Electrical & Computer Engineering

Degree Plan for Electrical Engineering (BSEE)

LAST NAME: _____ FIRST NAME: _____ STUDENT ID # _____ Catalog Year _____

**Degree plan will not be processed without declared degree catalog year

Approved by Advisor: _____(sign)_____(print) Date: _____

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CATERGORY 1: CONCENTRATION AREAS & REQUIRED CONCENTRATION ELECTIVES

Students must take **ALL** of the courses listed in this category in their chosen Concentration Area.

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	3441: Digital Logic Design				

CATEGORY 2: CONCENTRATION ELECTIVES

Students are free to choose from the following courses to complete (7) Concentration Electives in total.

Signals, Communications & Controls	Electronics	Nanosystems	Applied Electromagnetics	Power & Renewable Energy	Computers & Embedded Systems
Select 4	*Select 2*	*Select 3*	*Select 4*	*Select 3*	*Select 3*
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☐ 5451: Internetworking	☐ 5358: Modern Optics & Photonics	☐ 5356: CMOS Analog Integrated Circuits	☐ 5344 Signal Integrity		☐ 5436: Advanced Microprocessor Systems
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ECE ELECTIVES

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ECE ELECTIVE	ECE ELECTIVE

TECHNICAL ELECTIVE

Students must take one of the following courses.

☐ ECE _____ Any ECE 3000-, 4000-, or 5000-level course	☐ ENGI 2334 Intro to Thermodynamics	☐ MATH 3364 Complex Analysis	☐ MATH 4364 Numerical Analysis
☐ PHYS 3312 Modern Optics	☐ PHYS 3315 Modern Physics I	☐ MATH 3335 Vector Analysis	☐ MECE 3400 Intro to Mechanics

ELECTIVE LABS

Your elective choices must include at least **four** labs. Please list these here.

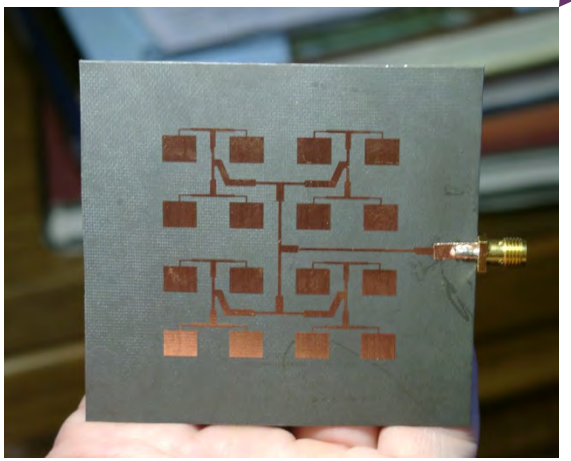
ECE LAB	ECE LAB
ECE LAB	ECE LAB

Applied Electromagnetics

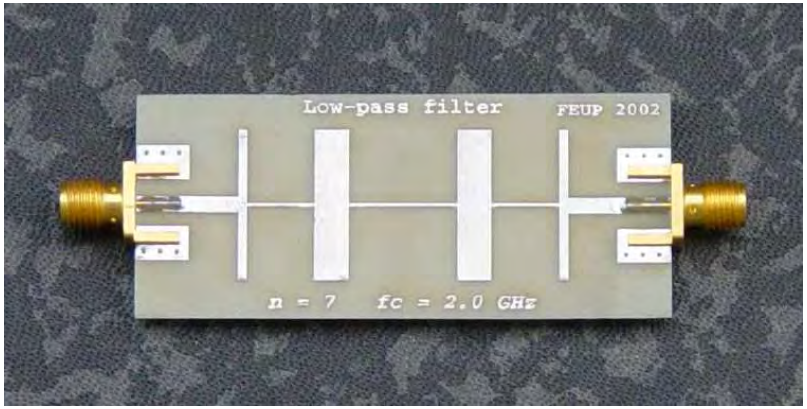
A cell-phone base-station antenna.

A microwave integrated circuit.

High Frequency



A microstrip antenna array.



A microwave filter constructed from microstrip.

Applied Electromagnetics

Power buses in a substation.

A transformer in a substation.

Low Frequency

Overhead high-voltage power lines

Large AC generators at Hoover Dam.

Applied Electromagnetics

High-frequency EM

- **ECE 5317: Microwave Engineering**
  Prereq: ECE 3317. Transmission lines, waveguides, microstrip circuits, microwave circuit theory, scattering matrices, impedance transformers, resonators, and filters.

- **ECE 5318: Antenna Engineering**
  Prereq: ECE 3317. Antenna concepts, linear wire antennas, linear arrays, aperture and horn antennas, microstrip antennas, dielectric resonator antennas, frequency-independent antennas, and measurement techniques.

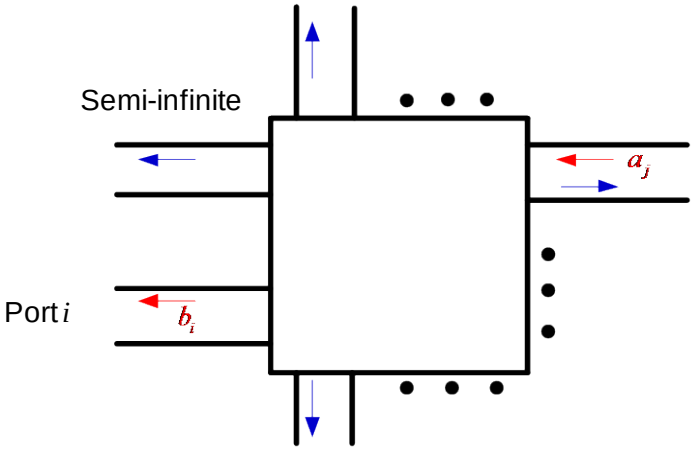
Applied Electromagnetics

High-frequency EM

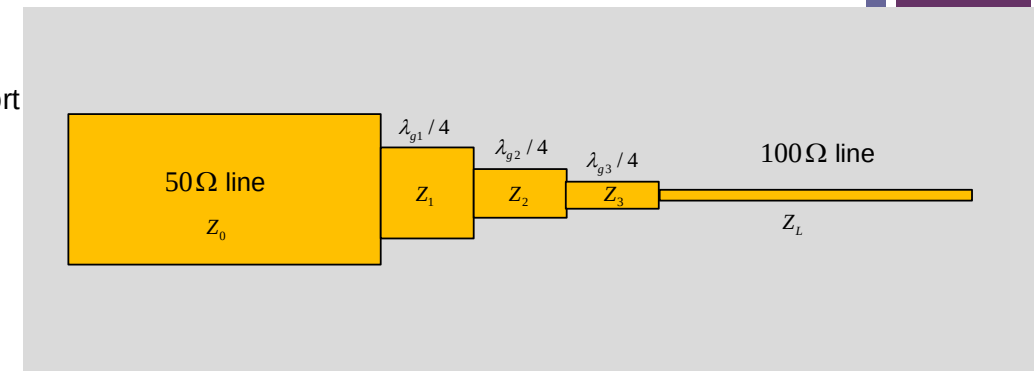
- **Microwave Engineering** focuses on the design of microwave circuits and devices. These include active devices such as oscillators, amplifiers, mixers, etc., as well as passive components such as resonators, couplers, filters, and multiplexers.
  - Microwave engineers work in a wide variety of companies, since much of the modern electronic equipment that we have operates at microwave frequencies.
  - ECE 5317 provides a good introduction to this area.
  - ECE 5113 is the Microwave Engineering lab course. This is a software lab, where student learn to use HFSS, a leading commercial software tool for EM analysis. This lab course is optional. It requires credit for or enrollment in ECE 5317.

Applied Electromagnetics

From ECE 5317

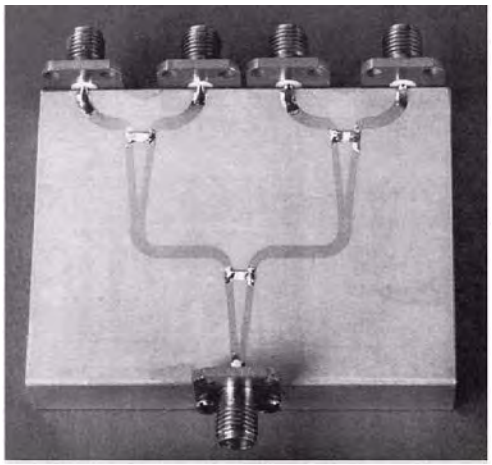


Scattering parameters



Broadband impedance transformer

Quadrature hybrid

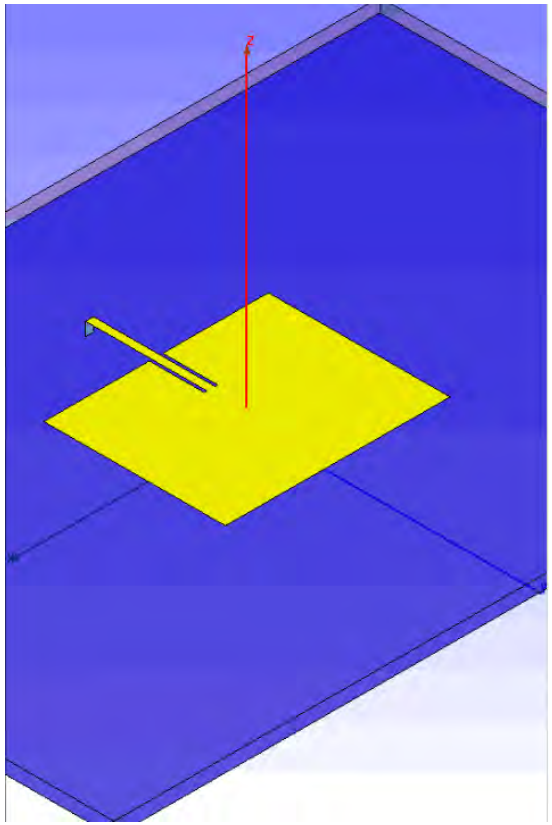


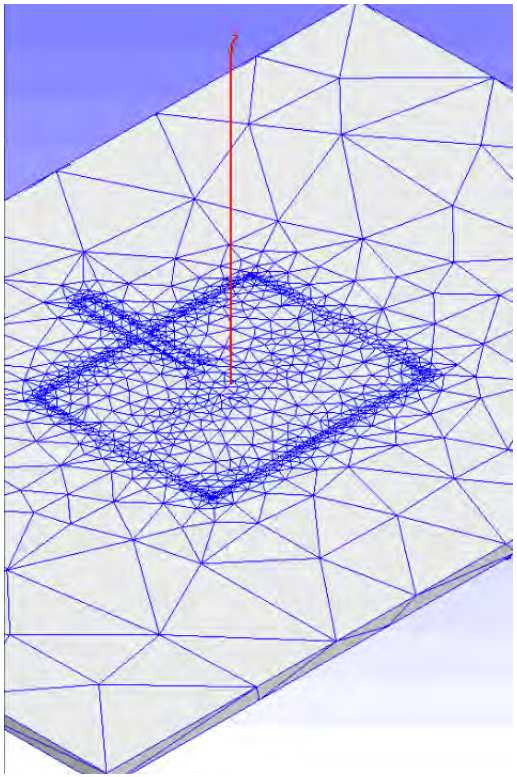
Wilkinson power dividers

Applied Electromagnetics

From ECE 5113

HFSS is a commercial EM simulation tool.





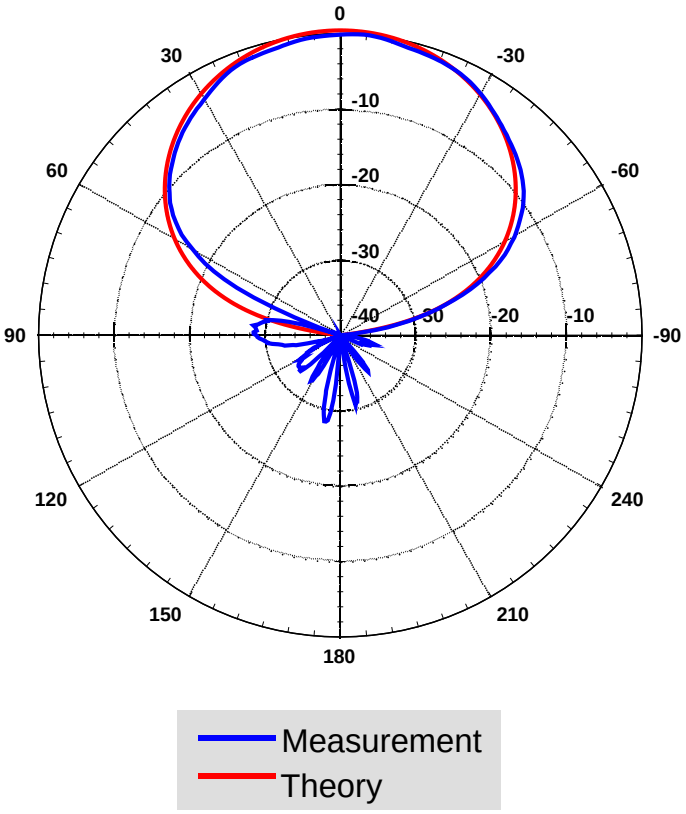
Applied Electromagnetics

High-frequency EM

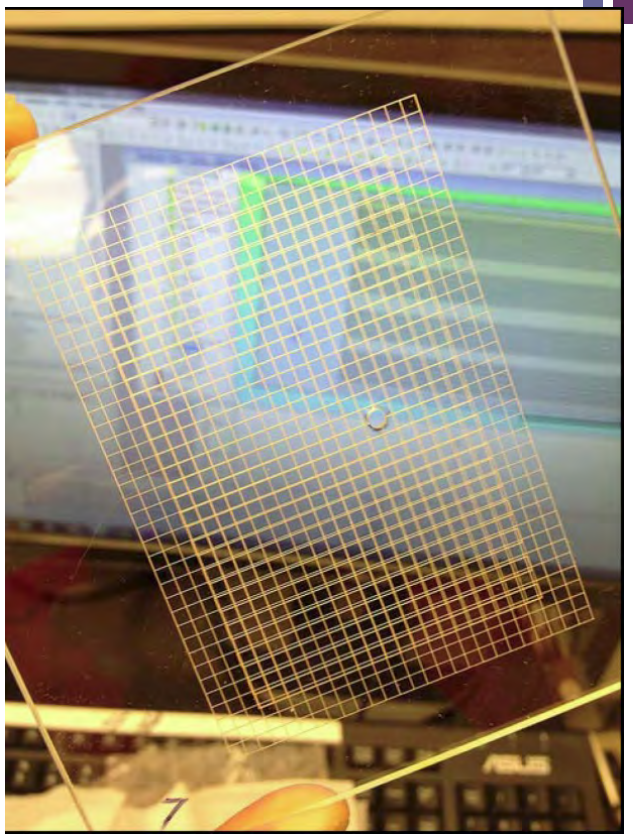
- **Antenna Engineering** focuses on antenna analysis and design. Antennas are used extensively in wireless communications, aerospace, and defense (military) areas. Antenna engineers often work in one of these areas.
  - ECE 5318 provides a good background for those wishing to go into the antenna area.
  - ECE 5318 is also good for those who simply want to know more about antennas (which are often a part of many sensor and communication systems).

Applied Electromagnetics

From ECE 5318



Radiation pattern of microstrip antenna



Transparent microstrip antenna for CubeSat

Applied Electromagnetics

Low-frequency EM

- **ECE 3318: Applied Electricity and Magnetism**
  Prereq: ECE 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 coupling and magnetic circuits, transformers, AC generators, motors.

Note: ECE 3318 can be taken at the same time as ECE 3317 (or before).

Applied Electromagnetics

Low-frequency EM

- 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

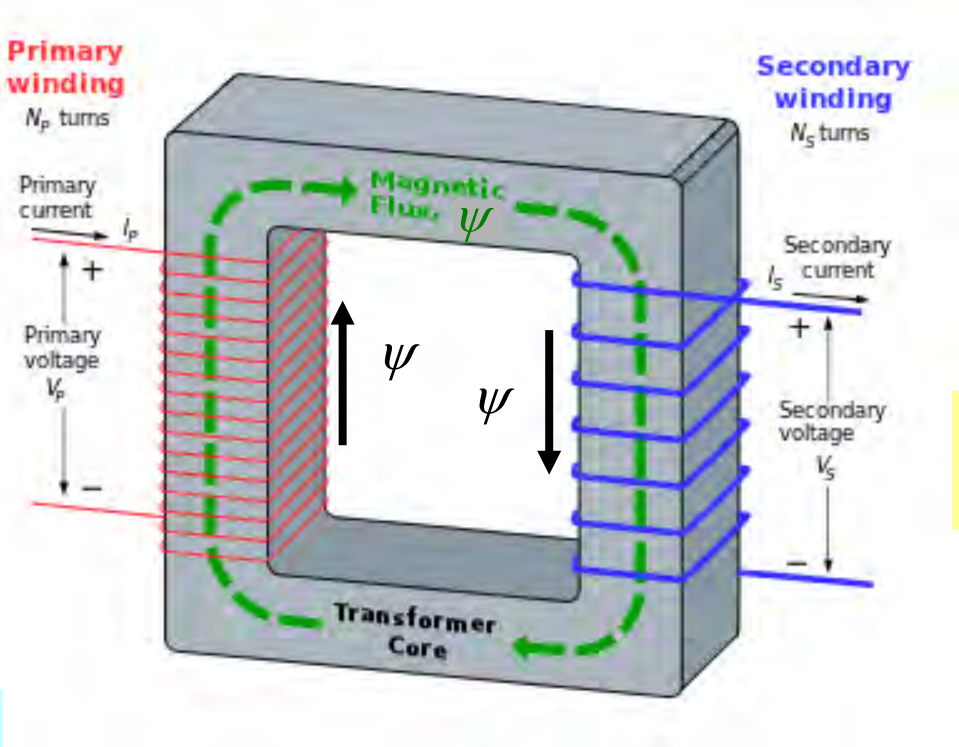
- ECE 3318 provides an introduction to low-frequency electromagnetics, covering basic electrostatic and magnetostatic principles.
- ECE 3318 also provides a good foundation for all other EM courses, though it is not required for them.

Applied Electromagnetics

From ECE 3318

Ideal Transformer

$$v_p(t) = N_p \frac{d\psi}{dt}$$



$$v_s(t) = N_s \frac{d\psi}{dt}$$

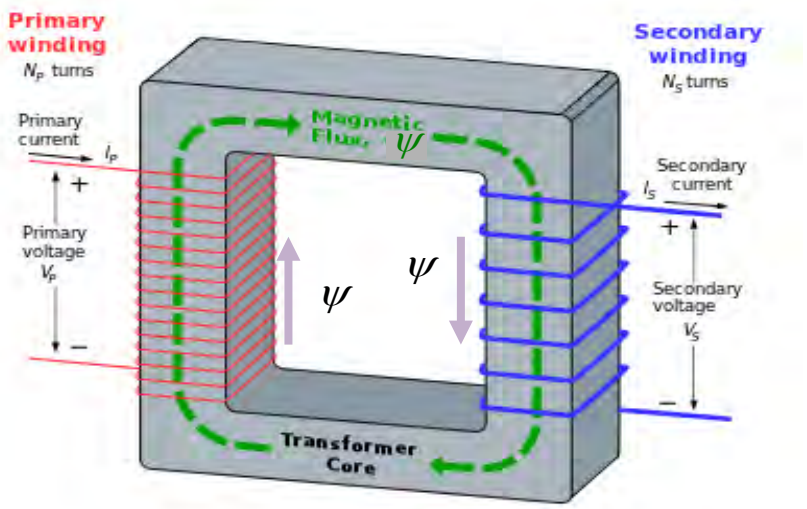
Hence:

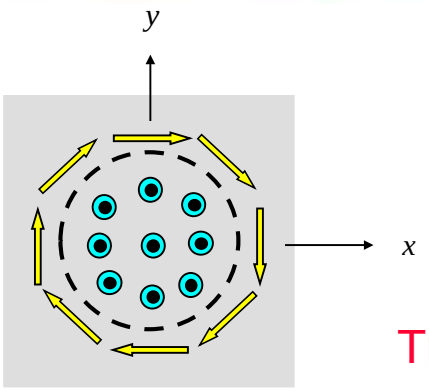
$$\frac{v_s(t)}{v_p(t)} = \frac{N_s}{N_p}$$

http://en.wikipedia.org/wiki/Transformer

Applied Electromagnetics

From ECE 3318





Transformer core

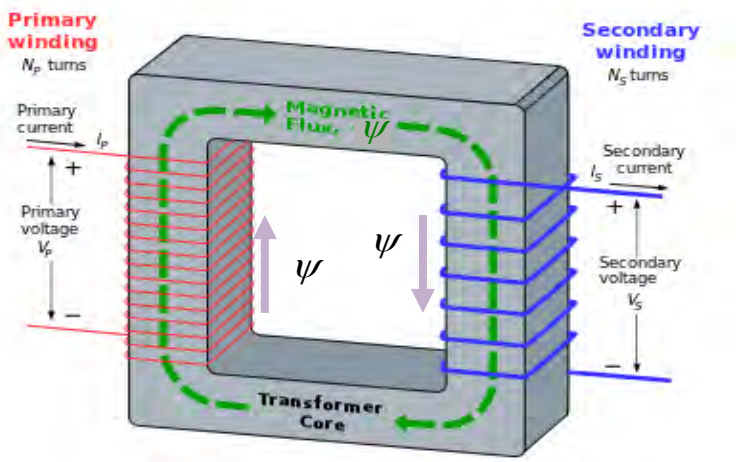
Eddy Currents

$$\oint_C \underline{E} \cdot d\underline{r} = -\frac{d\psi}{dt} = -\frac{d}{dt}\left(\pi\rho^2 B_z\right)$$

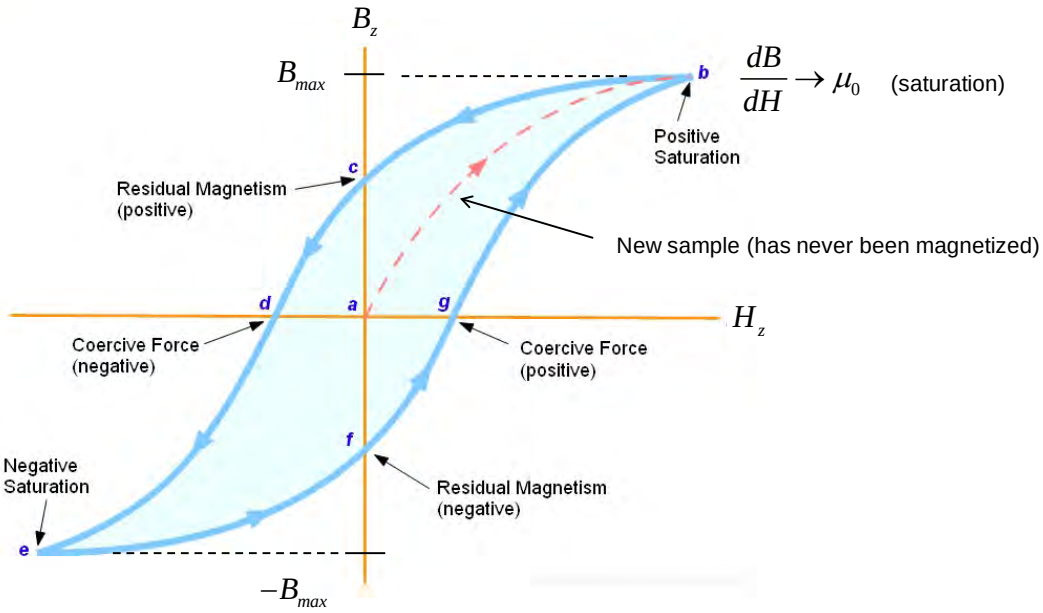
$$J_\phi^p = -j\left(\frac{\sigma\omega\rho}{2}\right)B_z^p$$

Applied Electromagnetics

From ECE 3318



Hysteresis



$$P_{\text{hysteresis}}^{\text{ave}} = A_h f V_c \ [\text{W}]$$

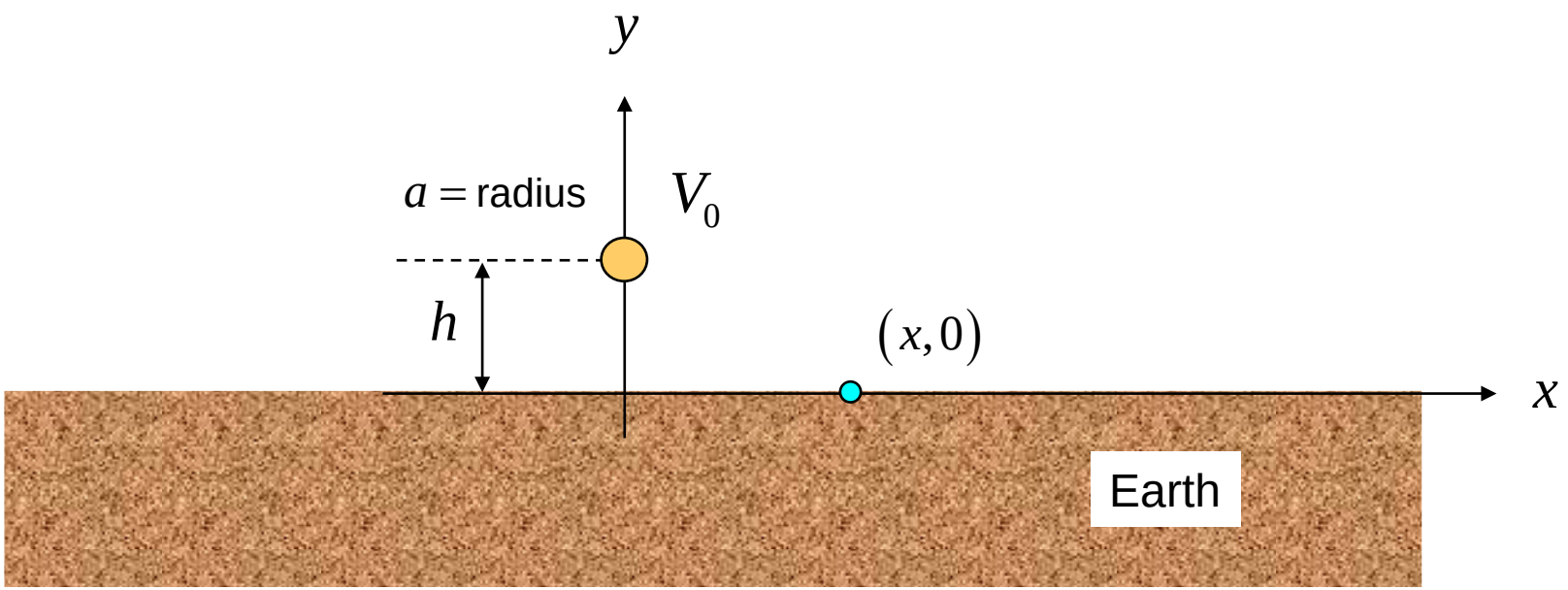
A_h = area of hysteresis curve

Applied Electromagnetics

From ECE 3318

Power Line over the Earth

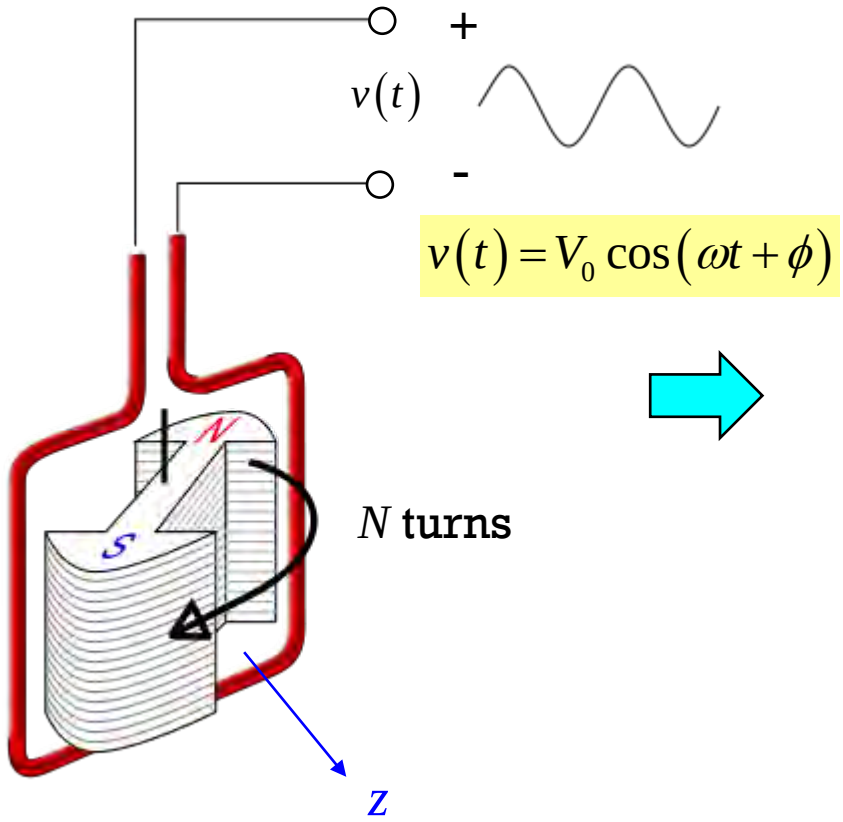
$$\underline{E}(x,0) = -\underline{\hat{y}}\left(\frac{1}{h}\right)\frac{2V_0}{\ln\left(\dfrac{2h-a}{a}\right)}\left(\frac{1}{1+(x/h)^2}\right)$$



Applied Electromagnetics

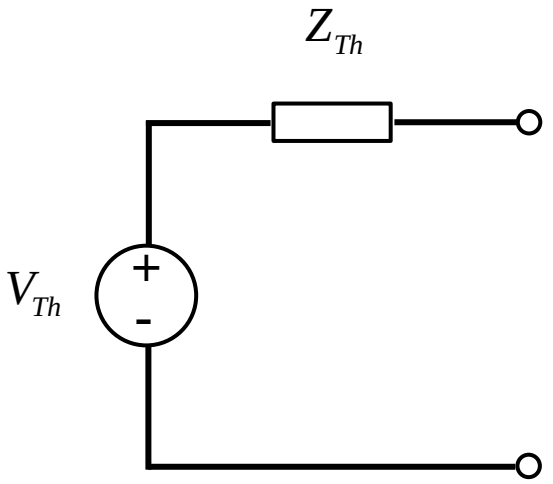
From ECE 3318

Thévenin Equivalent Circuit of AC Generator



$v(t) = V_0 \cos(\omega t + \phi)$

N turns



$$V_{Th} = V_0 e^{j\phi}$$

Z_{Th} = impedance of coil

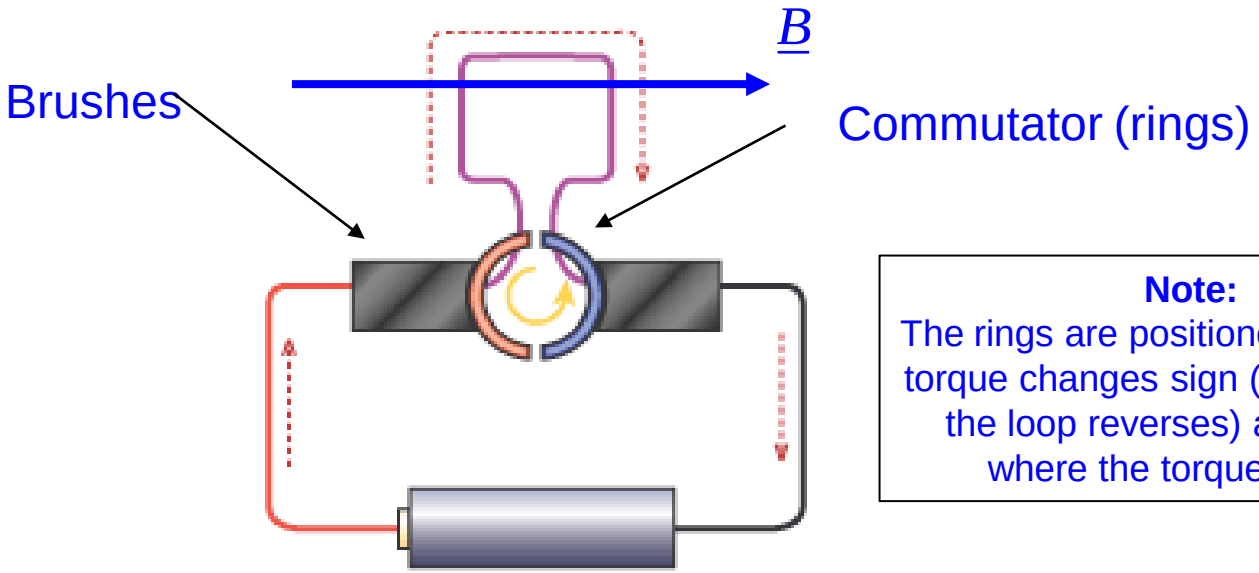
A = area of loop

http://en.wikipedia.org/wiki/Alternator

Applied Electromagnetics

From ECE 3318

DC Motor



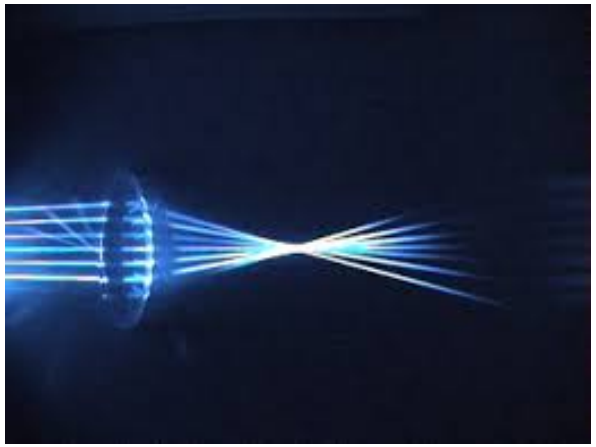
Note:
The rings are positioned so that the torque changes sign (the current in the loop reverses) at the point where the torque is zero.

The *commutator* reverses the loop current every 180° of rotation.
(It keeps the current flowing clockwise in the picture above.)

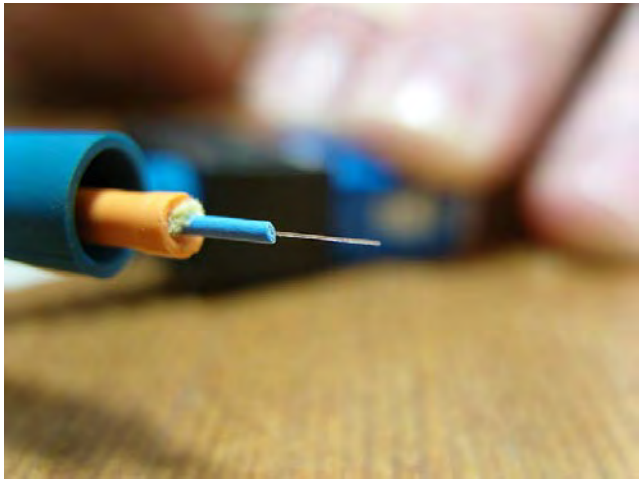
$$\underline{T} = -\hat{\underline{z}}\left(AIB_0\right)\left|\sin\phi\right|$$

http://en.wikipedia.org/wiki/Commutator_(electric)

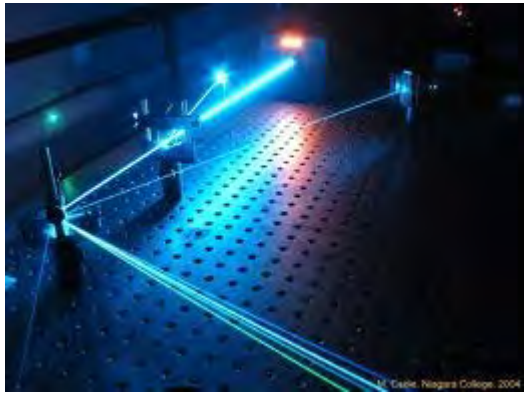
Optics



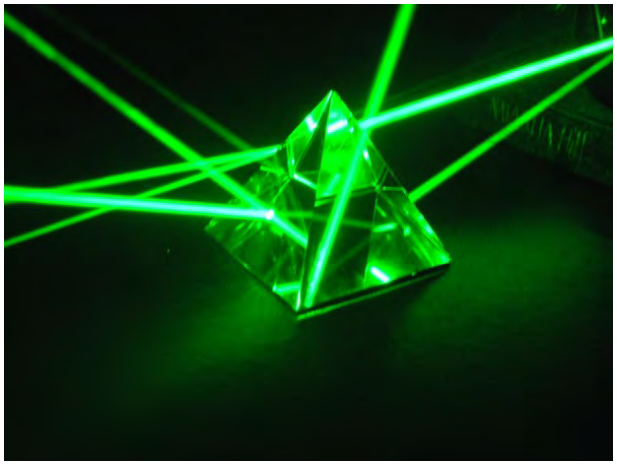
Lens.



Fiber optics.



Lasers.



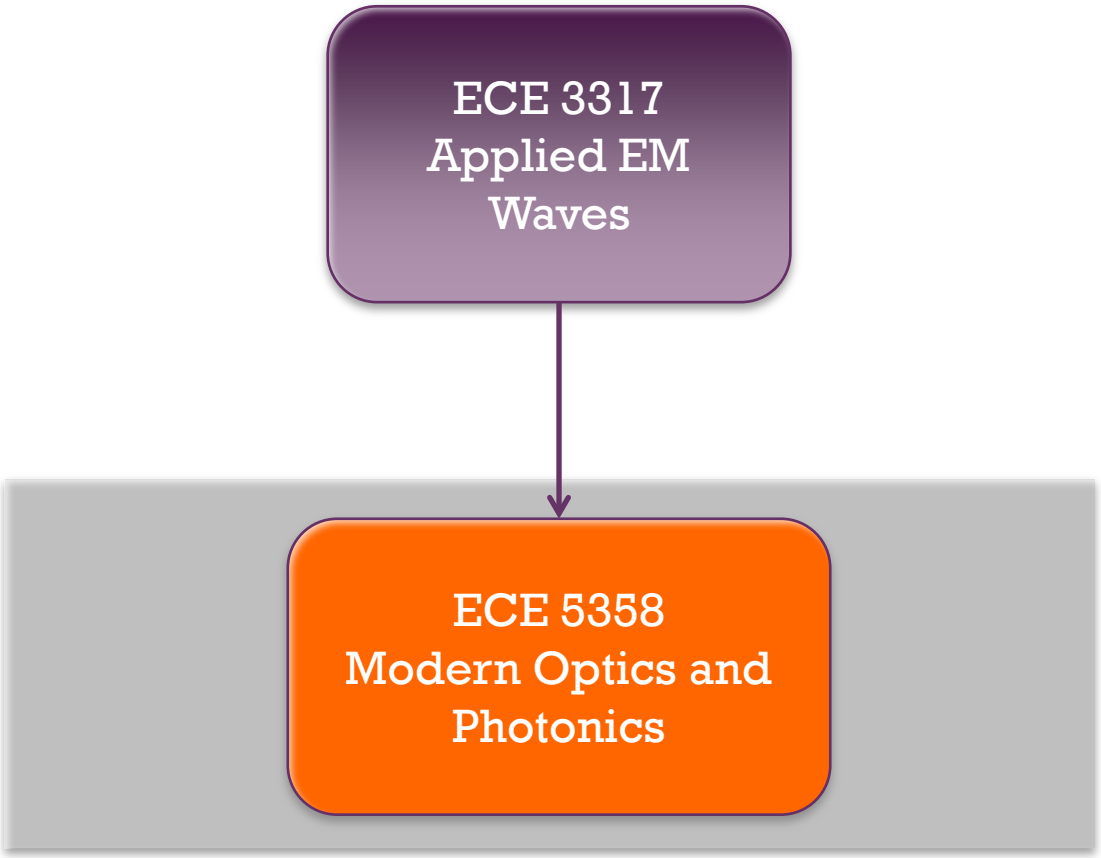
Optical reflection and refraction.

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.

This can be used a an elective course.

Optics


ECE 3317
Applied EM
Waves
ECE 5358
Modern Optics and
Photonics

Applied Electromagnetics

EM Graduate Course

- **ECE 6340: Intermediate Electromagnetics**
  - ◊ Maxwell's equations
  - ◊ Properties of matter
  - ◊ Poynting theorem and complex power
  - ◊ Transmission lines
  - ◊ Waveguides
  - ◊ Plane waves
  - ◊ Skin effect and surface impedance
  - ◊ Radiation from antennas
  - ◊ Duality
  - ◊ Image methods
  - ◊ Equivalence principle
  - ◊ Reciprocity
  - ◊ Far-field radiation from sources in layered media

As an undergraduate student, you are allowed to take graduate courses with permission of the instructor.

Applied Electromagnetics

Accelerated Masters Program

- This program allows you to double-count up to two 6000 level courses for both your undergraduate degree and your MSEE degree.
- These courses count as two of your undergraduate electives.
- This saves you 6 hours in your MSEE program.
- You must apply for this program and be accepted before you take these two courses.
- These two courses must be 6000 level courses, even when there is a 5000 level version (e.g., you must take ECE 6351 instead of ECE 5317; ECE 6352 instead of ECE 5318).

+

Power & Renewable Energy

Power

Power transmission and distribution.

Power electronics.

Motors and generators

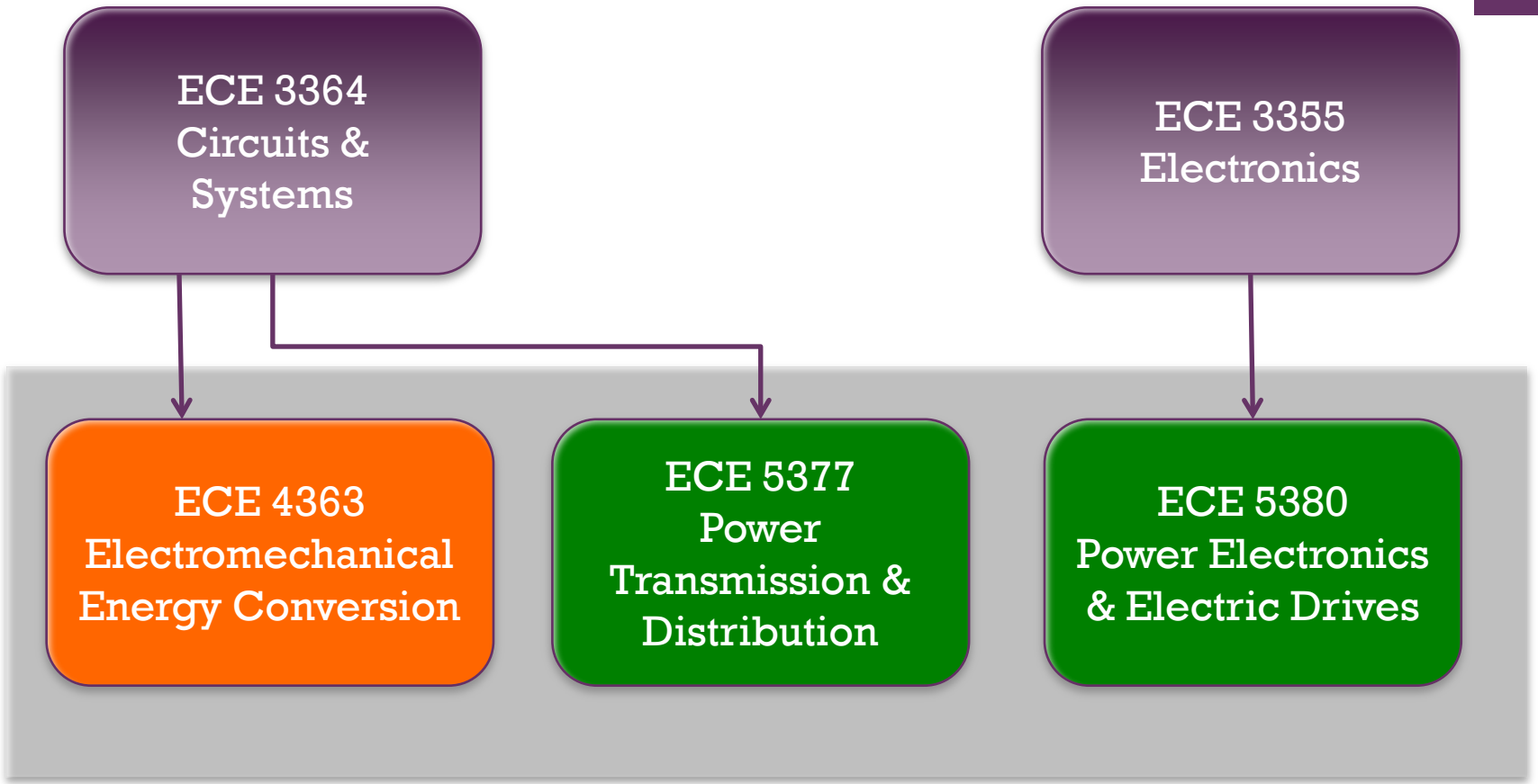
Power

- **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: 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.

Power


ECE 3364
Circuits &
Systems
ECE 3355
Electronics
ECE 4363
Electromechanical
Energy Conversion
ECE 5377
Power
Transmission &
Distribution
ECE 5380
Power Electronics
& Electric Drives

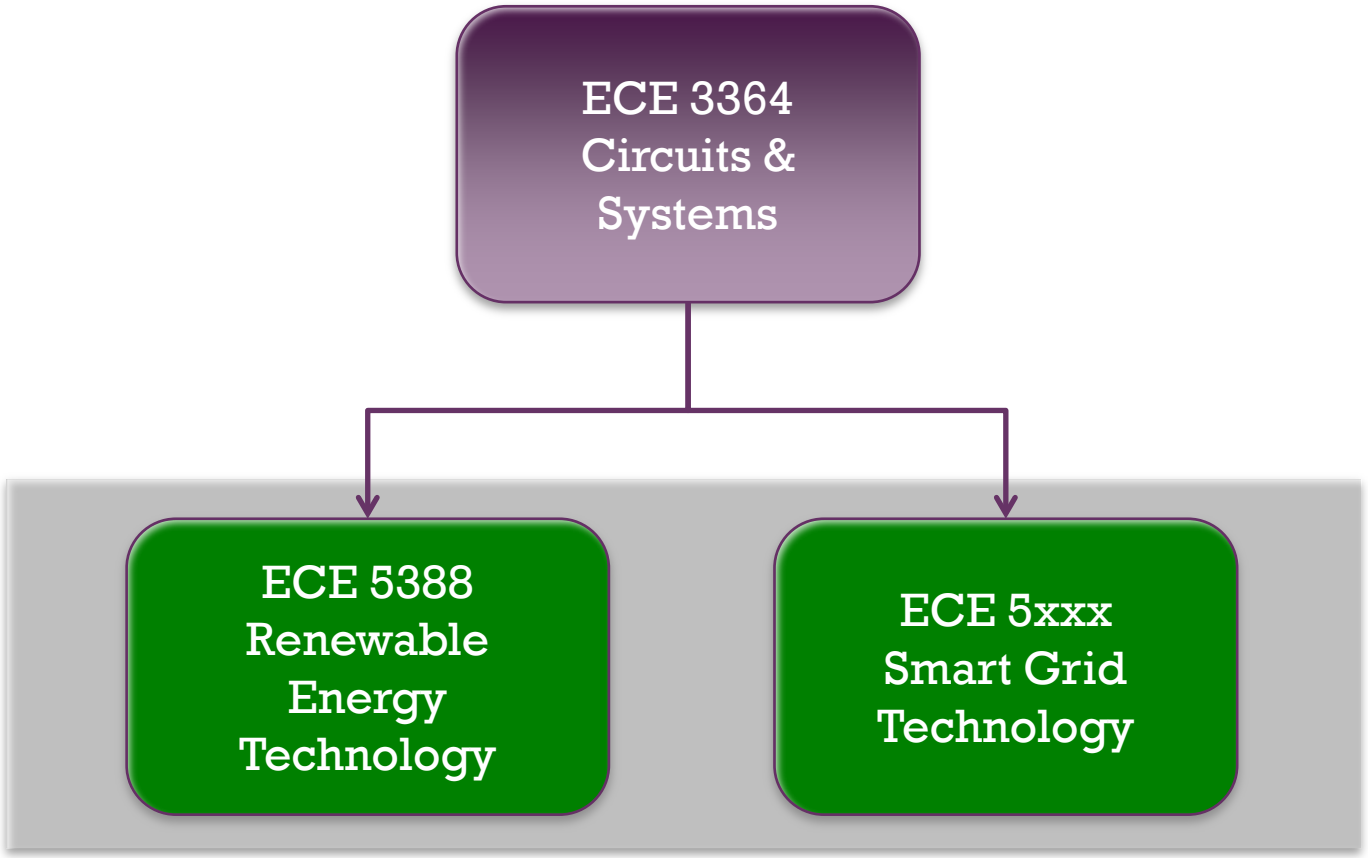
Power

- 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: Smart Grid Technology**
  Prereq: ECE 3364. Details to be determined.

Renewable Energy



Computers & Embedded Systems

Computers & Embedded Systems

Laptop computer.

Robonaut.

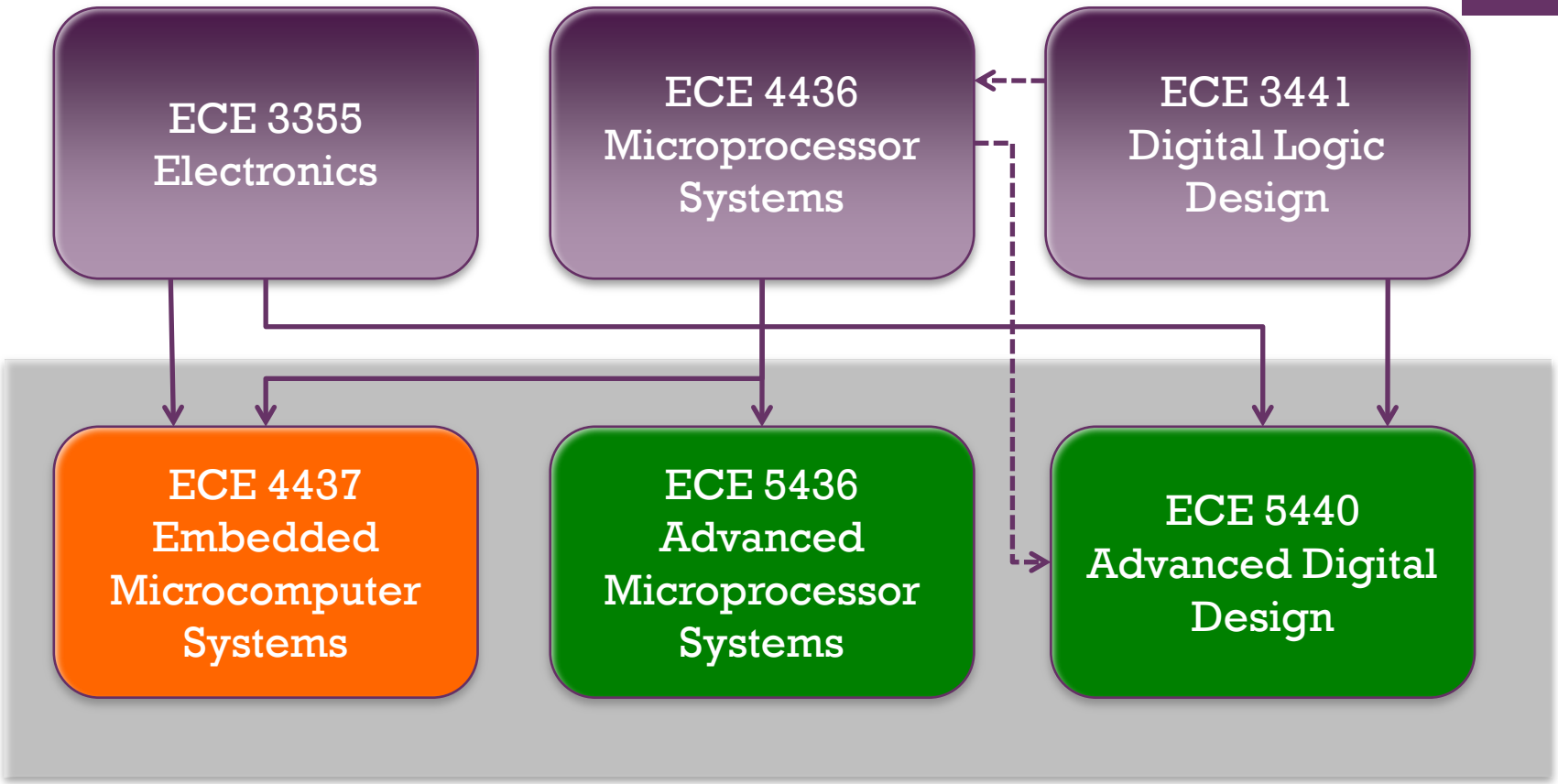
Well-logging tool.

Automobile with multiple embedded systems.

Computers & Embedded Systems

- **ECE 4437 (to become 5437): 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



Computers & Embedded Systems

- 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-logging tools), biomedical instrumentation, NASA-related design (Robonaut), telecommunications, and many others. ECE 4437 and 5440 are good preparation for work in those areas.