ELECTRICAL & COMP. ENGINEERING (ELEC)

ELEC 101 - ELEMENTS OF ELECTRICAL ENGINEERING
Short Title: ELEMENTS OF ELECT ENGINEERING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment limited to students with a class of Freshman or Sophomore. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Introduction to fundamentals of electrical engineering through the hands-on design of a micro-controlled model electric car. Topics from fields of circuits, signals, computing, and sensing are covered as needed to support the student in designing systems to power, monitor, and control the vehicle's speed, and to guide its trajectory, in order to pass a series of vehicle tests. Instructor Permission Required.

ELEC 220 - FUNDAMENTALS OF COMPUTER ENGINEERING
Short Title: FUND COMPUTER ENGINEERING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to students with a major in Computer Science, Engineering Division, Electrical & Computer Eng. or Electrical Engineering. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: An overview of computer engineering, starting with fundamental building blocks including transistors, bits, data representation, logic and state machines, progressing to computer organization, instruction sets, interrupts, input/output, assembly language programming, and linkage conventions, and ending with an introduction to architectural performance enhancements and computing services.
Course URL: www.owlnet.rice.edu/~elec220

ELEC 238 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Laboratory, Lecture, Seminar, Internship/Practicum
Credit Hours: 1-4
Course Level: Undergraduate Lower-Level
Description: Repeatable for Credit.

ELEC 240 - FUNDAMENTALS OF ELECTRICAL ENGINEERING I LABORATORY
Short Title: FUND EE I LAB
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): (MATH 101 or MATH 105) and (MATH 102 or MATH 106)
Corequisite: ELEC 241
Description: Laboratory course that introduces basic electronic measurement techniques and demonstrates the principles of information management by electronic means. Lectures supplement the laboratory experiments.

ELEC 241 - FUNDAMENTALS OF ELECTRICAL ENGINEERING I
Short Title: FUND ELECTRICAL ENGINEERING I
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): (MATH 101 or MATH 105) and (MATH 102 or MATH 106)
Corequisite: ELEC 240
Description: The creation, manipulation, transmission, and reception of information by electronic means, elementary signal theory; time and frequency-domain analysis; sampling theorem. Digital information theory; digital transmission of analog signals; error-correcting codes.

ELEC 242 - FUNDAMENTALS OF ELECTRICAL ENGINEERING II
Short Title: FUND ELECTRICAL ENGINEERING II
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): ELEC 241
Corequisite: ELEC 244
Description: Formulation and solution of equations describing electric circuits and electromechanical systems. Behavior of dynamic systems in the time and frequency domains. Basic electronic devices and circuits, including diodes, transistors, optoelectronics, gates, and amplifiers. Introduction to feedback control and digital systems. Students must register for both ELEC 242 and ELEC 244.
ELEC 262 - INTRODUCTION TO WAVES AND PHOTONICS
Short Title: INTRO TO WAVES AND PHOTONICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): (PHYS 101 or PHYS 111 or PHYS 125 or PHYS 141) and (PHYS 102 or PHYS 112 or PHYS 126 or PHYS 142)
Description: Introduction to the concepts of waves and oscillatory motion with a particular focus on electromagnetic waves and their interaction with dielectric materials, and on the use of these ideas in the fields of optical fiber communications, laser design, non-linear optics, and Fourier optics.

ELEC 301 - SIGNALS, SYSTEMS, AND LEARNING
Short Title: SIGNALS, SYSTEMS, AND LEARNING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (PHYS 102 or PHYS 112 or PHYS 126 or PHYS 142)
Corequisite: ELEC 303
Description: Analytical framework for analyzing signals and systems. Time and frequency domain analysis of continuous and discrete time signals and systems, convolution, and the Laplace and Z transforms. Introduction to algorithms for machine learning on signals, including clustering, regression, and classification. Instructor Permission Required.

ELEC 303 - RANDOM SIGNALS IN ELECTRICAL ENGINEERING SYSTEMS
Short Title: RANDOM SIGNALS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 241 and (MATH 354 or MATH 355 or CAAM 334 or CAAM 335)
Corequisite: ELEC 301
Description: An introduction to probability theory and statistics with applications to electrical engineering problems in signal processing, communications and control; probability spaces, conditional probability, independence, random variables, distribution and density functions, random vectors, signal detection and parameter estimation. ELEC 301 may be taken concurrently with ELEC 303.
ELEC 305 - INTRODUCTION TO PHYSICAL ELECTRONICS
Short Title: INTRO PHYSICAL ELECTRONICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 261 and MATH 212
Description: Survey of devices and physical principles that are used in modern electronic systems such as cellphones: diodes, transistors, integrated circuits; scaling and Moore's Law; transmission lines; signal integrity; antennas.

ELEC 306 - APPLIED ELECTROMAGNETICS
Short Title: APPLIED ELECTROMAGNETICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 214 and MATH 212
Description: Principles will be illustrated with applications in various areas. Topics include computational electromagnetics, transmission lines, antennas, electromagnetic interference, and signal propagation in high speed circuits.

ELEC 323 - PRINCIPLES OF PARALLEL PROGRAMMING
Short Title: FUNDAMENTALS OF PARALLEL PROG
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): COMP 211 or COMP 215
Description: Fundamentals of parallel programming: abstract models of parallel computers, parallel algorithms and data structures, and common parallel programming patterns including task parallelism, undirected and directed synchronization, data parallelism, divide-and-conquer parallelism, and map-reduce. Laboratory assignments will explore these topics through the use of parallel extensions to the Java language. Cross-list: COMP 322. Recommended Prerequisite(s): COMP 221.

ELEC 326 - DIGITAL LOGIC DESIGN
Short Title: DIGITAL LOGIC DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 220
Description: Introduction to the theory of static and dynamic switching circuits, registers, logical and arithmetic operations, and introduction to the Verilog hardware description language. Cross-list: COMP 326.

ELEC 327 - IMPLEMENTATION OF DIGITAL SYSTEMS
Short Title: IMPLEMENTATION OF DIGITAL SYS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 326 or COMP 326
Description: Embedded microsystems are widely employed to provide intelligence to sensors and actuators throughout our daily life. In this course, we learn the software and hardware frameworks which underly embedded systems design. Students will learn the fundamentals of embedded system programming and feel competent to design, build, and manufacture their own embedded devices. In particular, we focus on principles of low-power design and interface with external peripherals. In addition, students will learn how to design their own manufacturable hardware and discover how application-specific blocks enable modern commercial devices to function. There are weekly lab assignments and two projects. Instructor Permission Required.

ELEC 332 - ELECTRONIC SYSTEMS PRINCIPLES AND PRACTICE
Short Title: ELEC SYS PRINCIPLES & PRACTICE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 242
Description: This course covers the theory and techniques necessary to realize modern, high performance electronic systems. Design considerations for systems utilizing high speed, high frequency analog and digital integrated circuits will be covered. Students develop a microcontroller system for controlling the functions of a model electric car. Power and sensor circuits will be designed to monitor and control the vehicle's speed, and to guide its trajectory, in order to pass a series of vehicle tests. Instructor Permission Required.
### ELEC 342 - ANALOG ELECTRONIC CIRCUITS
**Short Title:** ANALOG ELECTRONIC CIRCUITS  
**Department:** Electrical & Computer Eng.  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture/Laboratory  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** ELEC 242 or ELEC 243  
**Description:** The course starts with a review of 1st order and 2nd order linear circuits. It emphasizes time-domain techniques and discusses step and impulse responses, reviews basic device physics of a CMOS transistor, followed by a derivation of current-voltage equations. The course also covers an in-depth analysis of large-signal behavior, linearization, and small signal models. Furthermore, it discusses single-stage and multi-stage amplifiers as well as differential amplifiers, common mode rejection ratio (CMRR), and techniques for increasing gain and improving linearity.

### ELEC 361 - QUANTUM MECHANICS FOR ENGINEERS
**Short Title:** QUANTUM MECHANICS FOR ENGINEER  
**Department:** Electrical & Computer Eng.  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** ELEC 261  
**Description:** This course provides the background in quantum mechanics and solid state physics necessary for further studies in semiconductor optoelectronic devices, quantum electronics, nanoscience, and photonics. Examples include: electronic energy levels in semiconductor quantum wells and superlattices; tunneling phenomena in semiconductor devices; the Kronig-Penney model; crystal momentum, effective mass, and Bloch oscillations; band structure of graphene and carbon nanotubes; and introduction to quantum information science.  
**Course URL:** [www.ece.rice.edu/~kono/ELEC361.html](http://www.ece.rice.edu/~kono/ELEC361.html)

### ELEC 364 - PHOTONICS MEASUREMENTS: PRINCIPLES AND PRACTICE
**Short Title:** PHOTONICS MEASUREMENTS  
**Department:** Electrical & Computer Eng.  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** ELEC 262 or PHYS 201  
**Description:** After completing this course, students will have the knowledge and experimental skills to design and apply a photonic measurement system to monitor an environment, process, device, or system. The course will combine predefined labs to develop skills with application projects. Instructor Permission Required.

### ELEC 365 - NANOMATERIALS FOR ENERGY
**Short Title:** NANOMATERIALS FOR ENERGY  
**Department:** Electrical & Computer Eng.  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture/Laboratory  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** This course will introduce students to the fundamental science of nanomaterials. Many of the concepts will be explained by drawing from applications in sustainability (photovoltaics, solar-to-fuel conversion thermionic, thermoelectric, fuel cells). Students will design a lab demo from scratch using amongst others the infrastructure provided by the photonics measurement lab. Cross-list: MSNE 365.

### ELEC 380 - INTRODUCTION TO NEUROENGINEERING: MEASURING AND MANIPULATING NEURAL ACTIVITY
**Short Title:** INTRO TO NEUROENGINEERING  
**Department:** Electrical & Computer Eng.  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** (PHYS 101 or PHYS 111 or PHYS 125 or PHYS 141) and (PHYS 102 or PHYS 112 or PHYS 126 or PHYS 142)  
**Description:** This course will serve as an introduction to quantitative modeling of neural activity and the methods used to stimulate and record brain activity. Cross-list: BIOE 380, NEUR 383. Graduate/Undergraduate Equivalency: ELEC 587. Mutually Exclusive: Credit cannot be earned for ELEC 380 and BIOE 480/BIOE 590/ELEC 480/ELEC 580/ELEC 587.

### ELEC 381 - FUNDAMENTALS OF NERVE AND MUSCLE ELECTROPHYSIOLOGY
**Short Title:** FUND OF ELECTROPHYSIOLOGY  
**Department:** Electrical & Computer Eng.  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** An introduction to cellular electrophysiology. Includes development of whole-cell models for neurons and muscle (cardiac and skeletal muscle) cells, based on ion channel currents obtained from whole-cell voltage-clamp experiments. Material balance equations are developed for various ions and chemical signaling agents (e.g., second messengers). Numerical methods are introduced for solving the ordinary and partial differential equations associated with these models. Several types of cell models are discussed ranging from neurons and muscle cells to sensory cells of mechanoreceptors, auditory hair cells and photoreceptor cells. Volume conductor boundary-value problems frequently encountered in electrophysiology are posed. Course provides a cellular basis for the interpretation of macroscopic bioelectric signals such as the electrocardiogram (ECG), electromyogram (EMG), electroretinogram (ERG) and electroencephalogram. Cross-list: BIOE 381.
ELEC 382 - INTRODUCTION TO COMPUTATIONAL NEUROSCIENCE
Short Title: INTRO COMPUTATIONAL NEURSCI
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Introduction to methods and theories used to describe and understand neural information processing in the brain. Models covered will range from single neuron to networks for sensory, motor and learning tasks. Programming exercises will be done using Matlab. Cross-list: NEUR 382. Recommended Prerequisite(s): CAAM 210. Mutually Exclusive: Credit cannot be earned for ELEC 382 and NEUR 582.

ELEC 395 - TRANSFER CREDIT - JUNIOR
Short Title: TRANSFER CREDIT - JUNIOR
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Transfer
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course is intended for transfer credit for courses not offered at Rice. Permission of ECE Undergraduate Committee and review by faculty in related specialization area is required. ELEC 395 is for Junior level ECE Specialization course credit. Department Permission Required. Repeatable for Credit.

ELEC 410 - SECURE AND CLOUD COMPUTING
Short Title: SECURE & CLOUD COMPUTING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): COMP 327 or COMP 427 or COMP 541 or COMP 429 or COMP 556 or ELEC 429 or ELEC 556 or COMP 421 or COMP 521 or ELEC 552 or ELEC 421 or ELEC 437 or ELEC 539
Description: What is "cloud computing?" How do we build cloud-scale systems and components that are secure against malicious attacks, and scale to millions of users? Many of today's services run inside the cloud – a set of geographically distributed data centers running heterogeneous software stacks. Cloud systems must scale across tens of thousands of machines, support millions of concurrent requests, and they must do so with high security guarantees. This course will start with the fundamentals of cloud computing, introduce key techniques in building scalable and secure systems and expose students to state-of-the-art research advances as well as emerging security threats and defenses in today's cloud systems. Mutually Exclusive: Credit cannot be earned for ELEC 410 and ELEC 510.

ELEC 411 - MICROWAVE ENGINEERING
Short Title: MICROWAVE ENGINEERING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Topics covered include transmission line, Smith Chart, scattering parameters, impedance matching, passive microwave circuits (power divider, coupler, 180° hybrid, filter), and antenna design fundamentals. Graduate/Undergraduate Equivalency: ELEC 517. Recommended Prerequisite(s): ELEC 262 or ELEC 305 or equivalent courses with the key concepts of Maxwell's Equations and Linear Algebra Mutually Exclusive: Credit cannot be earned for ELEC 411 and ELEC 517.

ELEC 419 - INNOVATION LAB FOR MOBILE HEALTH
Short Title: INNOVATION LAB - MOBILE HEALTH
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 3
Restrictions: Students with a class of Freshman may not enroll. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course will be an innovation lab for mobile health products. The students will organize themselves in groups with complementary skills and work on a single project for the whole semester. The aim will be to develop a product prototype which can then be demonstrated to both medical practitioners and potential investors. For successful projects with an operational prototype, the next steps could be applying for OWLspark (Rice accelerator program) or crowd sourcing (like Kickstarter) and/or work in Scalable Health Labs over summer. ELEC Juniors can also continue the project outcomes as a starting point for their senior design. Cross-list: BIOE 419. Graduate/Undergraduate Equivalency: ELEC 559. Mutually Exclusive: Credit cannot be earned for ELEC 419 and ELEC 559. Repeatable for Credit.
Course URL: www.ece.rice.edu/~ashu/ELEC419.html

ELEC 421 - OPERATING SYSTEMS AND CONCURRENT PROGRAMMING
Short Title: OP SYS/CONCURRENT PROGRAMMING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): COMP 215 and (COMP 221 or COMP 321)
Description: Introduction to the design, construction, and analysis of concurrent programs with an emphasis on operating systems, including filing systems, schedulers, and memory allocators. Specific attention is devoted to process synchronization and communication within concurrent programs. Cross-list: COMP 421. Graduate/Undergraduate Equivalency: ELEC 552. Mutually Exclusive: Credit cannot be earned for ELEC 421 and ELEC 552.
Course URL: www.clear.rice.edu/comp421/
ELEC 422 - VLSI SYSTEMS DESIGN
Short Title: VLSI SYSTEMS DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 326 or COMP 326
Description: A study of VLSI technology and design. MOS devices, Characteristics and fabrication. Logic design and implementation. VLSI design methodology, circuit simulation and verification. Graduate/Undergraduate Equivalency: ELEC 527. Mutually Exclusive: Credit cannot be earned for ELEC 422 and ELEC 527.

ELEC 423 - DIGITAL INTEGRATED CIRCUITS
Short Title: DIGITAL INTEGRATED CIRCUITS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 220 and ELEC 242 and (ELEC 326 or COMP 326)
Description: This course introduces students to the analysis and design of digital integrated circuits. We look at how CMOS devices are fabricated and how they operate physically, as well as how to design high-performance and low-power circuits. Various types of memory devices and designs are also covered in the course. Recommended Prerequisite(s): ELEC 305 or ELEC 261.

ELEC 424 - MOBILE AND EMBEDDED SYSTEM DESIGN AND APPLICATION
Short Title: MOBILE & EMBEDDED SYSTEM
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 220
Description: ELEC 424 introduces mobile and embedded system design and applications to undergraduate students and provides them hands-on design experience. It consists of three interlearning parts: lectures, student project, and student presentations. Cross-list: COMP 424. Graduate/Undergraduate Equivalency: ELEC 553. Mutually Exclusive: Credit cannot be earned for ELEC 424 and ELEC 553.
Course URL: www.ruf.rice.edu/~mobile/elec424/

ELEC 425 - COMPUTER SYSTEMS ARCHITECTURE
Short Title: COMPUTER SYSTEMS ARCHITECTURE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 326 or COMP 326
Description: Evolution of key architecture concepts found in advanced uniprocessor systems. Fundamental and advanced pipelining techniques and associated issues for improving processor performance. Illustrated with RISC processors such as the ARM processor. Examine several metrics for processor performance, such as Amdahl's law. Key concepts of data and program memory systems found in modern systems with memory hierarchies and caches. Perform experiments in cache performance analysis. Influence of technology trends, such as Moore's law, on processor implementation Approaches for exploiting instruction level parallelism, such as VLIW. Introduction to parallel and multicore architectures. Introduction to processor architectures targeted for imbedded applications. Cross-list: COMP 425. Graduate/Undergraduate Equivalency: ELEC 554. Mutually Exclusive: Credit cannot be earned for ELEC 425 and ELEC 554.

ELEC 427 - ADVANCED DIGITAL HARDWARE DESIGN, IMPLEMENTATION, AND OPTIMIZATION
Short Title: ADV DIGITAL DESIGN & IMPLEMENT
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 326 or COMP 326
Description: This senior level course will investigate design and implementation of modern digital signal processing, machine learning, and security algorithms in hardware (including FPGAs and ASICs). Along with learning the principals of design, students will acquire hands-on experience in hardware implementation and the use of the hardware in modern applications including but not limited to mobile phones, biomedical devices, and smart cards. Emphasis is on digital processors, design implementation on FPGA/ASIC fabrics and testing real systems on board, architectures, control, functional units, and circuit topologies for increased performance and reduced circuit size and power dissipation. Graduate/Undergraduate Equivalency: ELEC 555. Mutually Exclusive: Credit cannot be earned for ELEC 427 and ELEC 555. Repeatable for Credit.
ELEC 429 - INTRODUCTION TO COMPUTER NETWORKS
Short Title: INTRO TO COMPUTER NETWORKS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): COMP 221 or COMP 321
COMP 429. Graduate/Undergraduate Equivalency: ELEC 556. Mutually Exclusive: Credit cannot be earned for ELEC 429 and ELEC 556.
Course URL: www.clear.rice.edu/comp429/

ELEC 430 - MODERN COMMUNICATION THEORY AND PRACTICE
Short Title: MODERN COMM. THEORY & PRACTICE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 301 and ELEC 303
Description: Course in digital communications, designed to prepare students for engineering work in high-tech industries and for graduate work in communications, signal processing, and computer systems. Covers basic concepts and useful tools for design and performance analysis of transmitters and receivers in the physical layer of a communication system. Graduate/Undergraduate Equivalency: ELEC 551. Mutually Exclusive: Credit cannot be earned for ELEC 430 and ELEC 551.

ELEC 431 - DIGITAL SIGNAL PROCESSING
Short Title: DIGITAL SIGNAL PROCESSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 301
Description: Methods for analysis of discrete-time signals and design of discrete-time systems including topics of: discrete-time linear systems, difference equations, z-transforms, discrete convolution, stability, discrete-time Fourier transforms, analog-to-digital and digital-to-analog conversion, digital filter design, discrete Fourier transforms, fast Fourier transforms, multi-rate signal processing, filter banks, and spectral analysis. Graduate/Undergraduate Equivalency: ELEC 558. Mutually Exclusive: Credit cannot be earned for ELEC 431 and ELEC 558.

ELEC 432 - MOBILE BIO-BEHAVIORAL SENSING
Short Title: MOBILE BIO-BEHAVIORAL SENSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 301
Description: In the next-generation of devices, designed for diverse fields as healthcare and education, the devices will understand the human user. At the core of this understanding will be data that is gathered from a new class of sensors, that can measure both biological and behavioral markers. This course introduces the fundamentals of bio- and behavioral sensing. Graduate/Undergraduate Equivalency: ELEC 534. Mutually Exclusive: Credit cannot be earned for ELEC 432 and ELEC 302/ELEC 534.

ELEC 433 - ARCHITECTURE FOR WIRELESS COMMUNICATIONS
Short Title: ARCH - WIRELESS COMMUNICATIONS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 301 and (ELEC 326 or COMP 326)
Description: This is an FPGA laboratory course. Students will embark upon a detailed study and implementation of digital communications systems. Major functional blocks of end-to-end wireless communication systems will be discussed, built, and tested in hardware. Course will also cover analysis and design of communication systems, especially modulation, demodulation and detection. Students will benefit from a combined theory-lab approach to communications and work in groups on weekly lab assignments and a major semester project. Graduate/ Undergraduate Equivalency: ELEC 536. Mutually Exclusive: Credit cannot be earned for ELEC 433 and ELEC 536.

ELEC 434 - ADVANCED HIGH-SPEED SYSTEM DESIGN
Short Title: ADV H-S SYSTEM DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 305 and ELEC 244
Description: This course covers practical aspects of high-speed system design, highlights system design and simulation challenges, and demonstrates common pitfalls and how to prevent them. In this course, students will learn how to design, do gigahertz speed PCB layout, simulate (spice and Hyperlynx), and apply good design practices to minimize both component and system noise and to ensure system design success. Graduate/Undergraduate Equivalency: ELEC 543. Mutually Exclusive: Credit cannot be earned for ELEC 434 and ELEC 543.
ELEC 435 - INTRODUCTION TO ENERGY-EFFICIENT MECHATRONICS
Short Title: INTRO TO MECHATRONICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 242 or ELEC 243
Description: Introduction to electromechanical systems, focusing on motor mechanics, electric drives & electronics, & modern digital control algorithms. Covers basic principles of electromechanical energy conversion & motor control. Students are introduced to energy efficiency considerations of modern electric drives. Includes hands-on laboratory projects involving digital computer control of various motor types.
Mutually Exclusive: Credit cannot be earned for ELEC 435 and ELEC 532.

ELEC 436 - FUNDAMENTALS OF CONTROL SYSTEMS
Short Title: FUNDAMENTALS OF CONTROL SYST
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (CAAM 335 and MECH 343) or (CAAM 335 and ELEC 242 and ELEC 244)
Description: Linear systems and the fundamental principles of classical feedback control, state variable analysis of linear dynamic systems, stability of linear control systems, time-domain analysis and control of linear systems, root-locus analysis and design and pole-zero synthesis, frequency domain techniques for the analysis and design of control systems. Required for mechanical engineering majors in B.S. program.
Cross-list: MECH 420.

ELEC 437 - INTRODUCTION TO COMMUNICATION NETWORKS
Short Title: INTRO TO COMMUNICATION NETWORK
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 303
Description: Introduction to design and analysis of communication networks. Topics include wireless networks, media access, routing traffic modeling, congestion control, and scheduling. Graduate/Undergraduate Equivalency: ELEC 539. Mutually Exclusive: Credit cannot be earned for ELEC 437 and ELEC 539.

ELEC 438 - WIRELESS NETWORKING FOR UNDER-RESOURCED URBAN COMMUNITIES
Short Title: WIRELESS NETWKG UNDER-RESRC'D
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: The Rice Networks Group and the non-profit organization Technology For All have recently deployed a state-of-the art wireless network in one of Houston’s most economically disadvantaged neighborhoods. The objective of this network is to empower under-resourced communities with access to technology and educational and work-at-home tools. In this course project teams will perform measurement studies both in the Rice Networks Lab and in the East End neighborhood to characterize the system capacity; optimize placement of wireless nodes; study the effects of traffic and channel characteristics on system-wide performance; and plan deployment of additional nodes to extend the coverage area.

ELEC 439 - DATA SCIENCE AND DYNAMICAL SYSTEMS
Short Title: DATA AND SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: In many applications one is faced with the task of simulating or controlling complex dynamical systems. Such applications include for instance, weather prediction, air quality management, VLSI chip design, molecular dynamics, active noise reduction, chemical reactors, etc. In all these cases complexity manifests itself as the number of first order differential equations which arise. Model (order) reduction (MOR) seeks to replace a large-scale system described in terms of differential or difference equations by a system of much lower dimension that has nearly the same response characteristics. The ensuing methods have been an indispensable tool for speeding up the simulations arising in various engineering applications involving large-scale dynamical systems. In this course we will develop the underlying approximation theory paying particular attention to its data-driven aspects. Graduate/Undergraduate Equivalency: ELEC 519. Recommended Prerequisite(s): ELEC 301 OR MATH 355 OR CAAM 335
ELEC 440 - ARTIFICIAL INTELLIGENCE
Short Title: ARTIFICIAL INTELLIGENCE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): COMP 310 and (STAT 310 or ECON 307 or ECON 382 or STAT 312 or STAT 331 or ELEC 331 or ELEC 303) and (MATH 354 or MATH 355 or CAAM 335)
Description: This is a foundational course in artificial intelligence, the discipline of designing intelligent agents. The course will cover the design and analysis of agents that do the right thing in the face of limited information and computational resources. The course revolves around two main questions: how agents decide what to do, and how they learn from experience. Tools from computer science, probability theory, and game theory will be used. Interesting examples of intelligent agents will be covered, including poker playing programs, bots for various games (e.g. WoW), DS1 – the spacecraft that performed an autonomous flyby of Comet Borrely in 2001, Stanley – the Stanford robot car that won the Darpa Grand Challenge, Google Maps and how it calculates driving directions, face and handwriting recognizers, Fedex package delivery planners, airline fare prediction sites, and fraud detectors in financial transactions. Cross-list: COMP 440. Graduate/Undergraduate Equivalency: ELEC 557. Mutually Exclusive: Credit cannot be earned for ELEC 440 and ELEC 557.
Course URL: www.owlnet.rice.edu/~comp440

ELEC 442 - INTRODUCTION TO ANALOG INTEGRATED CIRCUITS
Short Title: ANALOG INTEGRATED CIRCUITS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 242
Description: There has been growing interest in analog computing in both academia and industry in the era of artificial intelligence. This course provides a comprehensive introduction to various aspects of modern analog integrated circuits. Students will learn how to 1) analyze, simulate and design a complementary metal oxide semiconductor (CMOS) analog integrated circuit, 2) analyze and simulate elementary transistor stages, current mirrors, supply- and temperature-independent bias and reference circuits, and 3) explore performance evaluation using computer-aided design tools. Graduate/Undergraduate Equivalency: ELEC 516. Mutually Exclusive: Credit cannot be earned for ELEC 442 and ELEC 516.

ELEC 446 - MOBILE DEVICE APPLICATIONS PROJECT
Short Title: MOBILE DEVICE APPLICATIONS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Connected mobile devices require updated programming models and design concepts to take advantage of their capabilities. We will explore applications primarily on the Apple iPhone and iPad but will also cover smart watches, Google Android and intelligent voice assistants like Amazon Echo and Google Home. We will briefly touch on the development of web services to support mobile applications. The course culminates with a large project taking up most of the second half of the semester. Although the curriculum centers around and teaches iOS and Xcode, final projects may be completed in any major mobile system including Android and Alexa, etc. Cross-list: COMP 446. Recommended Prerequisite(s): COMP 310 or prior Object Oriented Programming experience highly recommended.

ELEC 447 - INTRODUCTION TO COMPUTER VISION
Short Title: INTRO TO COMPUTER VISION
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 301 or ELEC 475 or COMP 314 or ELEC 322 or ELEC 345/ELEC 546
Description: An introduction to the basic concepts, algorithms and applications in computer vision. Topics include: cameras, camera models and imaging pipeline, low-level vision/image processing methods such as filtering and edge detection; mid-level vision topics such as segmentation and clustering; shape reconstruction from stereo, introduction to high-level vision tasks such as object recognition and face recognition. The course will involve programming and implementing basic computer vision algorithms in Matlab. Cross-list: COMP 447. Graduate/Undergraduate Equivalency: ELEC 546. Mutually Exclusive: Credit cannot be earned for ELEC 447 and ELEC 345/ELEC 546.
ELEC 450 - ALGORITHMIC ROBOTICS
Short Title: ALGORITHMIC ROBOTICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (COMP 221 or COMP 321) and COMP 215
Description: Robots have fascinated people for generations. Today, robots are built for applications as diverse as exploring remote planets, de-mining war zones, cleaning toxic waste, assembling cars, inspecting pipes in industrial plants and mowing lawns. Robots are also interacting with humans in a variety of ways: robots are museum guides, robots assist surgeon sin life threatening operations, and robotic cars can drive us around. The field of robotics studies not only the design of new mechanisms but also the development of artificial intelligence frameworks to make these mechanism useful in the physical world, integrating computer science, engineering, mathematics and more recently biology and sociology, in a unique way. This class will present fundamental algorithmic advances that enable today's robots to move in real environments and plan their actions. It will also explore fundamentals of the field of Artificial Intelligence through the prism of robotics. The class involves a significant programming project. Cross-list: COMP 450, MECH 450. Graduate/Undergraduate Equivalency: ELEC 550. Mutually Exclusive: Credit cannot be earned for ELEC 450 and ELEC 550.

ELEC 460 - PHYSICS OF SENSOR MATERIALS AND NANOSENSOR TECHNOLOGY
Short Title: PHYSICS OF SENSORS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 261 and ELEC 305
Description: Topics covered include MEMS, MOEMS, and NEMS systems along with special materials such as liquid crystals, piezoelectrics, memory metal, and topological insulators. Graduate/Undergraduate Equivalency: ELEC 560. Mutually Exclusive: Credit cannot be earned for ELEC 460 and ELEC 560.

ELEC 462 - OPTOELECTRONIC DEVICES
Short Title: OPTOELECTRONIC DEVICES
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 305
Description: This course provides an introduction to the fundamental principles of semiconductor optoelectronic devices. After reviewing the basic elements of quantum mechanics of electrons and photons, light-matter interaction (including laser oscillations), and semiconductor physics (band structure, heterostructures and alloys, optical processes), we will study the details of modern semiconductor devices for the generation, detection, and modulation of light. Graduate/Undergraduate Equivalency: ELEC 562. Mutually Exclusive: Credit cannot be earned for ELEC 462 and ELEC 562.
Course URL: www.ece.rice.edu/~kono/ELEC462.html

ELEC 475 - LEARNING FROM SENSOR DATA
Short Title: LEARNING FROM SENSOR DATA
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: The first half of this course develops the basic machine learning tools for signals images, and other data acquired from sensors. Tools covered include principal components analysis, regression, support vector machines, neural networks, and deep learning. The second half of this course overviews a number of applications of sensor data science in neuroscience, image and video processing, and machine vision. Graduate/Undergraduate Equivalency: ELEC 575. Mutually Exclusive: Credit cannot be earned for ELEC 475 and ELEC 575.

ELEC 477 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Lecture, Seminar, Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.
ELEC 478 - INTRODUCTION TO MACHINE LEARNING
Short Title: INTRO TO MACHINE LEARNING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (STAT 405 or CAAM 210 or COMP 140) and (CAAM 335 or MATH 355)
Description: This course covers advanced statistical signal processing and machine learning approaches for modern neuroscience data (primarily many-channel spike trains). Topics include latent variable models, point processes, Bayesian inference, dimensionality reduction, dynamical systems, and spectral analysis. Neuroscience applications include modeling neural firing rates, spike sorting, decoding. Graduate/Undergraduate Equivalency: ELEC 548. Recommended Prerequisite(s): ELEC 475 and STAT 413 and COMP 540 and (ELEC 242 or ELEC 243) Mutually Exclusive: Credit cannot be earned for ELEC 483 and ELEC 548.

ELEC 483 - MACHINE LEARNING AND SIGNAL PROCESSING FOR NEURO ENGINEERING
Short Title: NEURAL SIGNAL PROCESSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 354 or MATH 355 or CAAM 335) and (ELEC 303 or STAT 305 or STAT 310) and (CAAM 210 or COMP 140)
Description: This course covers advanced statistical signal processing and machine learning approaches for modern neuroscience data (primarily many-channel spike trains). Topics include latent variable models, point processes, Bayesian inference, dimensionality reduction, dynamical systems, and spectral analysis. Neuroscience applications include modeling neural firing rates, spike sorting, decoding. Graduate/Undergraduate Equivalency: ELEC 548. Recommended Prerequisite(s): ELEC 475 and STAT 413 and COMP 540 and (ELEC 242 or ELEC 243) Mutually Exclusive: Credit cannot be earned for ELEC 483 and ELEC 548.

ELEC 484 - FUNDAMENTALS OF HUMAN NEUROIMAGING
Short Title: HUMAN NEUROIMAGING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: A survey of methods and results for human brain imaging. Describes the physical and physiological mechanisms of image formation. Provides examples from clinical and basic research, particularly in visual cortex. Emphasis on magnetic resonance imaging, but surveys other imaging modalities including PET, optical, and EEG/MEG source localization. Course taught at Baylor College of Medicine. Cross-list: NEUR 430. Graduate/Undergraduate Equivalency: ELEC 584. Mutually Exclusive: Credit cannot be earned for ELEC 484 and ELEC 584.

ELEC 485 - FUNDAMENTALS OF MEDICAL IMAGING I
Short Title: FUND MEDICAL IMAGING I
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course will introduce basic principles of image acquisition, formation and processing of several medical imaging modalities such as X-Ray, CT, MRI, and US that are used to evaluate the human anatomy. The course also includes visits to a clinical site to gain experience with the various imaging modalities covered in class. Cross-list: BIOE 485, COMP 485. Graduate/Undergraduate Equivalency: ELEC 585. Recommended Prerequisite(s): MATH 211 and MATH 212. Mutually Exclusive: Credit cannot be earned for ELEC 485 and ELEC 585.
ELEC 486 - FUNDAMENTALS OF MEDICAL IMAGING II
Short Title: FUND MEDICAL IMAGING II
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 485 or BIOE 485 or COMP 485
Description: This course focuses on functional imaging modalities used specifically in nuclear medicine such as Gamma cameras, SPECT, and PET imaging. The course will introduce the basic principles of image acquisition, formation, processing and the clinical applications of these imaging modalities and lays the foundations for understanding the principles of radiotracer kinetic modeling. A trip to a clinical site in also planned to gain experience with nuclear medicine imaging. Cross-list: BIOE 486, COMP 486. Graduate/Undergraduate Equivalency: ELEC 586. Mutually Exclusive: Credit cannot be earned for ELEC 486 and ELEC 586.

ELEC 488 - THEORETICAL NEUROSCIENCE: FROM CELLS TO LEARNING SYSTEMS
Short Title: THEORETICAL NEUROSCIENCE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: We present the theoretical foundations of cellular and systems neuroscience from distinctly quantitative point of view. We develop the mathematical and computational tools as they are needed to model, analyze, visualize and interpret a broad range of experimental data. Cross-list: CAAM 415, NEUR 415. Graduate/Undergraduate Equivalency: ELEC 588. Recommended Prerequisite(s): CAAM 210 or MATH 211 or CAAM 335 or MATH 355. Mutually Exclusive: Credit cannot be earned for ELEC 488 and ELEC 588.

ELEC 489 - NEURAL COMPUTATION
Short Title: NEURAL COMPUTATION
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: How does the brain work? Understanding the brain requires sophisticated theories to make sense of the collective actions of billions of neurons and trillions of synapses. Word theories are not enough; we need mathematical theories. The goal of this course is to provide an introduction to the mathematical theories of learning and computation by neural systems. These theories use concepts from dynamical systems (attractors, oscillations, chaos) and concepts from statistics (information, uncertainty, inference) to relate the dynamics and functions of neural networks. We will apply these theories to sensory computation, learning and memory, and motor control. Students will learn to formalize and mathematically answer questions about neural computations, including “what does a network compute?”, “how does it compute?”, and “why does it compute that way?” Prerequisites: knowledge of calculus, linear algebra, and probability and statistics. Cross-list: CAAM 416, NEUR 416. Graduate/Undergraduate Equivalency: ELEC 589. Mutually Exclusive: Credit cannot be earned for ELEC 489 and ELEC 589.

ELEC 490 - UNDERGRADUATE ELECTRICAL ENGINEERING RESEARCH PROJECTS
Short Title: UG ELEC ENG’G RES PROJECTS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Theoretical and experimental investigations under staff direction. A research project plan should be prepared and approved by the faculty member advising the project. Information about ELEC 490 project plans is available on the ECE Web site on the Academics section under ECE forms. May be repeated for a total of 6 credit hours for undergraduates. Instructor Permission Required. Repeatable for Credit.

ELEC 491 - UNDERGRADUATE ELECTRICAL ENGINEERING RESEARCH PROJECTS-VERTICALLY INTEGRATED PROJECTS
Short Title: UG ELEC ENG’G RESEARCH VIP
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Vertically Integrated Projects (VIP) teams include students from multiple years working on one larger, multi-year project defined by the instructor. Students participating in VIP for 3 or more semesters may be eligible for the Distinction in Research and Creative Work graduation award. Instructor Permission Required. Graduate/Undergraduate Equivalency: ELEC 591. Mutually Exclusive: Credit cannot be earned for ELEC 491 and ELEC 591. Repeatable for Credit.
ELEC 494 - SENIOR DESIGN
Short Title: SENIOR DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Senior Design is a year-long course required of all BSEE-degree students. In order to fulfill the BSEE degree requirements, students must register for ELEC 494 for both fall and spring semesters of the same academic year. The course is taught in conjunction with the Senior Design courses in BioEngineering and in Mechanical Engineering and Materials Science. Teams of students will design, construct, and document a prototype system to meet specifications determined by the team and the instructor. Senior design projects are the culmination of the Rice engineering experience. Cross-departmental projects are allowed and encouraged, and extensive use will be made of the Oshman Engineering Design Kitchen. Many projects will involve advisors from industrial affiliates. Throughout the year there will be several opportunities for presentations on the project. Top projects will be eligible for several awards from within Rice and outside the university, including some nation-wide competitions. Instructor Permission Required. Repeatable for Credit.

ELEC 495 - TRANSFER CREDIT - SENIOR
Short Title: TRANSFER CREDIT - SENIOR
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Transfer
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course is intended for transfer credit for courses not offered at Rice. Permission of ECE Undergraduate Committee and review by faculty in related specialization area is required. ELEC 495 is for Senior level ECE Specialization course credit. Department Permission Required. Repeatable for Credit.

ELEC 497 - DESIGN OF ANALOG PRINTED CIRCUIT BOARDS
Short Title: ANALOG PRINTED CIRCUIT BOARDS
Department: Electrical & Computer Eng.
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Lecture/Laboratory
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): ELEC 494 (may be taken concurrently) or BIOE 451 (may be taken concurrently) or MECH 407 (may be taken concurrently)
Description: This course covers the basics of designing, fabricating, and testing daughter cards for microcontrollers such as the Arduino. Using PCB design software such as Eagle, students will design, fabricate, and test their printed circuit board. Prerequisites may be taken concurrently.

ELEC 498 - INTRODUCTION TO ROBOTICS
Short Title: INTRODUCTION TO ROBOTICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 354 or MATH 355 or CAAM 335
Description: This course will provide the student with a mathematical introduction to many of the key ideas used in today’s intelligent robot systems. The focus of the course is on the analysis and control of manipulators. The course will also give an overview of common approaches to building intelligent robot systems. Cross-list: COMP 498, MECH 498. Graduate/Undergraduate Equivalency: ELEC 598. Mutually Exclusive: Credit cannot be earned for ELEC 498 and ELEC 598.

ELEC 502 - NEURAL MACHINE LEARNING I
Short Title: NEURAL MACHINE LEARNING I
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Review of major neural machine learning (Artificial Neural Network) paradigms. Analytical discussion of supervised and unsupervised neural learning algorithms and their relation to information theoretical methods. Practical applications to data analysis such as pattern recognition, clustering, classification, function approximation/ regression, non-linear PCA, projection pursuit, independent component analysis, with lots of examples from image and digital processings. Details are posted at www.ece.rice.edu/~erzsebet/ANNcourse.html. Cross-list: COMP 502, STAT 502. Recommended Prerequisite(s): ELEC 430 and ELEC 431 or equivalent or permission of instructor.
Course URL: www.ece.rice.edu/~erzsebet/ANNcourse.html

ELEC 507 - NONLINEAR DYNAMIC SYSTEMS ANALYSIS
Short Title: NONLINEAR DYNAMIC SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Analytical methods for the study of nonlinear systems are introduced, including singular point and phase plane analysis, the describing function technique, Lyapunov and Lagrangian state functions, stability analysis, bifurcation analysis, and chaotic behavior in nonlinear dynamic systems. As a substrate for the study of nonlinear systems, numerical analysis of ordinary and partial differential equations, boundary value problems, simulation methods, parameter estimation and sensitivity analysis methods are also included.
ELEC 508 - NONLINEAR SYSTEMS: ANALYSIS AND CONTROL
Short Title: NONLINEAR SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate

ELEC 510 - SECURE AND CLOUD COMPUTING
Short Title: SECURE & CLOUD COMPUTING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): COMP 327 or COMP 427 or COMP 541 or COMP 429 or COMP 556 or ELEC 429 or ELEC 556 or COMP 421 or COMP 521 or ELEC 421 or COMP 552 or ELEC 437 or COMP 539
Description: What is “cloud computing”? How do we build cloud-scale systems and components that are secure against malicious attacks, and scale to millions of users? Many of today's services run inside the cloud – a set of geographically distributed data centers running heterogeneous software stacks. Cloud systems must scale across tens of thousands of machines, support millions of concurrent requests, and they must do so with high security guarantees. This course will start with the fundamentals of cloud computing, introduce key techniques in building scalable and secure systems and expose students to state-of-the-art research advances as well as emerging security threats and defenses in today’s cloud systems. Cross-list: COMP 536. Mutually Exclusive: Credit cannot be earned for ELEC 510 and ELEC 410.

ELEC 511 - DESIGN AND ANALYSIS OF SECURE EMBEDDED SYSTEMS FOR IoT ERA
Short Title: SECURE EMBEDDED SYS FOR IoT
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course emphasizes the security of small embedded devices that are central to the Internet of Things (IoT) Era. We discuss the practical security attacks, challenges, constraints, and opportunities that arise in the IoT domain. Covered topics include security engineering, real world attacks, practical and side channel attacks, and hands-on lab/projects. Cross-list: COMP 508. Repeatable for Credit.

ELEC 512 - GRADUATE DESIGN AND ANALYSIS OF ALGORITHMS
Short Title: GR DESGN ANALY OF ALGORITHMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): STAT 310 or ECON 307 or STAT 331 or ELEC 331 or ELEC 303 or STAT 312
Description: Methods for designing and analyzing computer algorithms and data structures. The focus of this course will be on the theoretical and mathematical aspects of algorithms and data structures. Cross-list: COMP 582.

ELEC 513 - COMPLEXITY IN MODERN SYSTEMS
Short Title: COMPLEXITY IN MODERN SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): COMP 582.
Description: A modern computer is a system with enormous complexity in both software and hardware. The course presents the principles for managing such complexity using examples from modern computing systems. It covers emergent issues from system complexity such as energy efficiency, bug finding, and heterogeneous hardware. It also covers designing experiments and writing systems papers. The course consists of lectures, student presentation of classic papers, and a final project. Cross-list: COMP 513.

ELEC 514 - WIRELESS INTEGRATED CIRCUITS AND SYSTEMS
Short Title: WIRELESS IC
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topics covered include system architectures for modern wireless transceivers and transistor-level design considerations for circuit building blocks (low noise amplifier, mixer, power amplifier, etc.) in a wireless transceiver. Recommended Prerequisite(s): ELEC 305, ELEC 342, or Equivalent Courses with the Key Concepts Listed Below • Transistor-level CMOS analog circuits (basic configurations, small signal models, parasitic effects) • Frequency response of transistor-level CMOS circuits (pole/zero calculations) • Frequency response of simple passive networks (1st order and 2nd order RLC networks) • Noise analysis of transistor-level CMOS circuits (noise sources in CMOS transistors, input referred voltage/current noise for CMOS transistor-level circuits)
ELEC 515 - ENERGY-EFFICIENT MACHINE LEARNING SYSTEMS
Short Title: ENERGY-EFFICIENT MACHINE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Machine learning is in tremendous demand in numerous applications; however, its often prohibitive complexity remains a major challenge for its extensive deployment in resource constrained platforms. This course will introduce techniques which enable the development of energy efficient machine learning systems, taking a path from algorithm to architecture down to the circuit level.

ELEC 516 - ANALOG INTEGRATED CIRCUITS
Short Title: ANALOG INTEGRATED CIRCUITS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): ELEC 342
Description: This course starts with an in-depth study of physics of P-N junctions and CMOS transistors. It covers transistor level analysis and design of analog circuits, with emphasis on intuitive design methods, quantitative performance measures, and practical circuit limitations. Students use hand calculations and computer simulations to compare the results. This course discusses low-frequency behavior of single-stage and multistage amplifiers, current sources, active loads, operational amplifiers, as well as supply and temperature and independent biasing. It also covers high-frequency response of amplifiers, feedback in electronic circuits, stability feedback amplifiers, and noise in electronic circuits. Graduate/Undergraduate Equivalency: ELEC 442. Mutually Exclusive: Credit cannot be earned for both ELEC 516 and ELEC 442.

ELEC 517 - MICROWAVE ENGINEERING
Short Title: MICROWAVE ENGINEERING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topics covered include transmission line, Smith Chart, scattering parameters, impedance matching, passive microwave circuits (power divider, coupler, 180° hybrid, filter), and antenna design fundamentals. Graduate/Undergraduate Equivalency: ELEC 411. Mutually Exclusive: Credit cannot be earned for ELEC 517 and ELEC 411.

ELEC 519 - DATA SCIENCE AND DYNAMICAL SYSTEMS
Short Title: DATA AND SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: In many applications one is faced with the task of simulating or controlling complex dynamical systems. Such applications include for instance, weather prediction, air quality management, VLSI chip design, molecular dynamics, active noise reduction, chemical reactors, etc. In all these cases complexity manifests itself as the number of first order differential equations which arise. Model (order) reduction (MOR) seeks to replace a large-scale system described in terms of differential or difference equations by a system of much lower dimension that has nearly the same response characteristics. The ensuing methods have been an indispensable tool for speeding up the simulations arising in various engineering applications involving large-scale dynamical systems. In this course we will develop the underlying approximation theory paying particular attention to its data-driven aspects. Additional coursework required beyond the undergraduate course requirements. Mutually Exclusive: Credit cannot be earned for both ELEC 519 and ELEC 439. Graduate/Undergraduate Equivalency: ELEC 439.

ELEC 520 - DISTRIBUTED SYSTEMS
Short Title: DISTRIBUTED SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): ELEC 439. Graduate/Undergraduate Equivalency: ELEC 439.
Course URL: www.cs.rice.edu/~alc/comp520/

ELEC 521 - ADVANCED DIGITAL INTEGRATED CIRCUITS DESIGN
Short Title: ADV DIGITAL IC DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course addresses advanced issues in custom digital IC design. Topics range from physical-level analysis and modeling of new devices, interconnect, and power supply, to circuit-level design techniques for low power and high performance, to application-oriented digital circuits/systems for security and machine learning. Recommended Prerequisite(s): ELEC 326/COMP 326 or ELEC 342 or Digital Circuit Courses.
ELEC 522 - ADVANCED VLSI DESIGN

Short Title: ADV VLSI DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Design and analysis of algorithm-specific VLSI processor architectures. Topics include the implementation of pipelined and systolic processor arrays. Techniques for mapping numerical algorithms onto custom processor arrays. Course includes design project using high-level VLSI synthesis tools.
Course URL: www.owlnet.rice.edu/~elec522

ELEC 524 - MOBILE AND WIRELESS NETWORKING

Short Title: MOBILE AND WIRELESS NETWORKING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): COMP 429 or ELEC 429
Description: Study of network protocols for mobile and wireless networking, particularly at the media access control, network, and transport protocol layers. Focus is on the unique problems and challenges presented by the properties of wireless transmission and host or router mobility. Cross-list: COMP 524. Recommended Prerequisite(s): COMP 421 OR ELEC 421.

ELEC 525 - VIRTUALIZATION AND CLOUD RESOURCE MANAGEMENT

Short Title: VIRTUAL & CLOUD RESOURCE MGMT
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): (ELEC 425 or COMP 425)

ELEC 526 - HIGH PERFORMANCE COMPUTER ARCHITECTURE

Short Title: HIGH PERFORM COMPUTER ARCH
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Design of high performance computer systems, including shared-memory and message-passing multiprocessors and vector systems. Hardware and software techniques to tolerate and reduce memory and communication latency. Case studies and performance simulation of high-performance systems. Cross-list: COMP 526. Recommended Prerequisite(s): ELEC 425 or COMP 425

ELEC 527 - VLSI SYSTEMS DESIGN

Short Title: VLSI SYSTEMS DESIGN
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A study of VLSI technology and design. MOS devices, characteristics and fabrication. Logic design and implementation. VLSI design methodology, circuit simulation and verification. Additional course work required beyond the undergraduate course requirement. Graduate/Undergraduate Equivalency: ELEC 422. Mutually Exclusive: Credit cannot be earned for ELEC 527 and ELEC 422.

ELEC 528 - SECURITY TOPICS OF EMBEDDED SYSTEMS

Short Title: EMBEDDED HW SYSTEMS SECURITY
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course covers wide range of topics pertaining to security of Hardware Embedded systems, including cryptographic processors, secure memory access, hardware IT protection by monitoring and watermarking FPGA security, physical and side-charmed attacks, Trojan horses. Cross-list: COMP 538. Repeatable for Credit.
Course URL: www.ece.rice.edu/~fk1/

ELEC 529 - ADVANCED COMPUTER NETWORKS

Short Title: ADVANCED COMPUTER NETWORKS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): COMP 429 or ELEC 429
Description: This course explores advanced solutions in computer networks that are driven by the need to go beyond the best-effort capabilities of the Internet. Topics include network fault tolerance, traffic engineering, scalable data center network architectures, network support for big data processing, network support for cloud computing, extensible network control via software defined networking, denial-of-service-attack defense mechanisms. Readings from original research papers. Also include design project and oral presentation components. This course assumes students already have a good understanding of the best-effort Internet. Cross-list: COMP 529. Repeatable for Credit.
Course URL: www.clear.rice.edu/comp529/

ELEC 530 - DETECTION THEORY

Short Title: DETECTION THEORY
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Classic and modern methods of optimal decisions in communications and signal processing. Continuous- and discrete-time methods. Gaussian and non-Gaussian problems.
ELEC 531 - STATISTICAL SIGNAL PROCESSING
Short Title: STATISTICAL SIGNAL PROCESSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Statistical models for single- and multi-channel signals. Optimal detection and estimation solutions for Gaussian and non-Gaussian environments. Recommended Prerequisite(s): ELEC 533 and knowledge of digital signal processing at the level of ELEC 431.

ELEC 532 - INTRODUCTION TO ENERGY-EFFICIENT MECHATRONICS
Short Title: INTRO TO MECHATRONICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to electromechanical systems, focusing on motor mechanics, electric drives & electronics, & modern digital control algorithms. Covers basic principles of electromechanical energy conversion & motor control. Students are introduced to energy efficiency considerations of modern electric drives. Includes hands-on laboratory projects involving digital computer control of various motor types. Additional coursework required beyond the undergraduate course requirements. Cross-list: MECH 535. Graduate/Undergraduate Equivalency: ELEC 435. Mutually Exclusive: Credit cannot be earned for ELEC 532 and ELEC 435.

ELEC 533 - INTRODUCTION TO RANDOM PROCESSES AND APPLICATIONS
Short Title: INTRO RANDOM PROCESSES & APPL
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Review of basic probability; Sequences of random variables; Random vectors and estimation; Basic concepts of random processes; Random processes in linear systems, expansions of random processes; Wiener filtering; Spectral representation of random processes, and white-noise integrals. Cross-list: CAAM 583, STAT 583.

ELEC 534 - MOBILE BIO-BEHAVIORAL SENSING
Short Title: MOBILE BIO-BEHAVIORAL SENSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: In the next-generation of devices, designed for diverse fields as healthcare and education, the devices will understand the human user. At the core of this understanding will be data that is gathered from a new class of sensors, that can measure both biological and behavioral markers. This course introduces the fundamentals of bio- and behavioral sensing. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 432. Mutually Exclusive: Credit cannot be earned for ELEC 534 and ELEC 432.

ELEC 535 - INFORMATION THEORY
Short Title: INFORMATION THEORY
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to information theory concepts; basic theorems of channel coding and source coding with a fidelity criterion. The course material requires background of a first course in probability, like Rice ELEC 303.

ELEC 536 - ARCHITECTURE FOR WIRELESS COMMUNICATIONS
Short Title: ARCH - WIRELESS COMMUNICATIONS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This is an FPGA laboratory course. Students will embark upon a detailed study and implementation of digital communications systems. Major functional blocks of end-to-end wireless communication systems will be discussed, built, and tested in hardware. Course will also cover analysis and design of communication systems, especially modulation, demodulation and detection. Students will benefit from a combined theory-lab approach to communications and work in groups on weekly lab assignments and a major semester project. Graduate/Undergraduate Equivalency: ELEC 433. Mutually Exclusive: Credit cannot be earned for ELEC 536 and ELEC 433.

ELEC 537 - COMMUNICATION NETWORKS
Short Title: COMMUNICATION NETWORKS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Graduate-level introduction to design and analysis of communication networks. Topics include wireless networks, medium access, routing, traffic modeling, congestion control, and scheduling. Cross-list: MECH 537.

ELEC 538 - ADVANCED TOPICS IN COMPUTER NETWORKING
Short Title: ADV TOP COMPUTER NETWORKING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Advanced topics in next generation mobile and wireless networks.
ELEC 539 - INTRODUCTION TO COMMUNICATION NETWORKS  
Short Title: INTRO TO COMMUNICATION NETWORK  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Introduction to design and analysis of communication networks. Topics include wireless networks, media access, routing traffic modeling, congestion control, and scheduling. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 437. Mutually Exclusive: Credit cannot be earned for ELEC 539 and ELEC 437.

ELEC 540 - ADVANCED WIRELESS COMMUNICATIONS  
Short Title: ADVANCED WIRELESS COMM  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Course will teach advanced techniques in wireless, e.g. MIMO, Massive MIMO, Full-duplex and Coordinated Multi-point. The focus will be on both the theoretical foundations and practical use in actual systems, explored with a combination of lectures, homeworks, data-driven evaluations and mini-projects. Recommended Prerequisite(s): ELEC 430 or ELEC 551 or ELEC 535.

ELEC 541 - ERROR CORRECTING CODES  
Short Title: ERROR CORRECTING CODES  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Prerequisite(s): ELEC 430  
Description: Introductory course on error correcting codes. Topics covered include linear block codes, convolutional codes, turbo codes and LDPC codes.

ELEC 542 - THE APPLICATION OF VECTOR SPACE METHODS AND OTHER ADVANCED TECHNIQUES TO DSP  
Short Title: VECTOR SPACES AND DSP  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Prerequisite(s): ELEC 431 (may be taken concurrently)  
Description: The course will introduce the application of vector space methods to digital signal processing. This includes topics such as representing a signal using basis expansions, Gram-Schmidt orthogonalization, linear inverse problems, gradient-descent, the use of regularization in approximation, and other advanced topics. The course may be taken in the same semester as ELEC 431.

ELEC 543 - ADVANCED HIGH-SPEED SYSTEM DESIGN  
Short Title: ADV H-S SYSTEM DESIGN  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: This course covers practical aspects of high-speed system design, highlights system design and simulation challenges, and demonstrates common pitfalls and how to prevent them. In this course, students will learn how to design, do gigahertz speed PCB layout, simulate (spice and Hyperlynx), and apply good design practices to minimize both component and system noise and to ensure system design success. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 434. Recommended Prerequisite(s): Knowledge of mixed analog/digital circuits, active filters and transmission line theories. Mutually Exclusive: Credit cannot be earned for ELEC 543 and ELEC 434.

ELEC 544 - ADVANCED DSP  
Short Title: ADVANCED DSP  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: The course will cover advanced topics in FIR and IIR digital filter design, advanced topics in signal processing algorithms, especially in FFTs and high speed convolution and correlation, and in wavelet based signal processing and the discrete wavelet transform. The course will be one-half lecture based and one-half project based.

ELEC 545 - THIN FILMS  
Short Title: THIN FILMS  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Deposition methods, structure, properties, performance and failure mechanisms of thin solid films for various applications. Deposition methods include sputtering, plating, evaporation and chemical vapor deposition. Material types include crystalline and amorphous metals as well as semiconductors and insulators. Applications are primarily in microelectronics; data storage; micro-electro-mechanical systems, wear and corrosion prevention and thermal barriers. NOTE: Not offered every year. Cross-list: MSNE 545.
ELEC 546 - INTRODUCTION TO COMPUTER VISION
Short Title: INTRO TO COMPUTER VISION
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: An introduction to the basic concepts, algorithms and applications in computer vision. Topics include: cameras, camera models and imaging pipeline, low-level vision/image processing methods such as filtering and edge detection; mid-level vision topics such as segmentation and clustering; shape reconstruction from stereo, introduction to high-level vision tasks such as object recognition and face recognition. The course will involve programming and implementing basic computer vision algorithms in Matlab. Additional coursework required beyond the undergraduate course requirements. Additional coursework required beyond the undergraduate requirements. Cross-list: COMP 546. Graduate/Undergraduate Equivalency: ELEC 447. Mutually Exclusive: Credit cannot be earned for ELEC 546 and ELEC 447.

ELEC 547 - COMPUTER VISION
Short Title: COMPUTER VISION
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The goal of computer vision is to make sense of the three dimensional world from captured images and videos. This requires understanding how light interacts with objects in the environment and then captured by a camera. The goal is to solve problems such as estimating 3D shape of an environment (How does Kinect work?), how to detect and recognize people (How to build your own iPhoto?), detect and track how things move. The course provides an introduction to solving such problems using vision tools such as feature detection, image segmentation, motion estimation, image mosaics, 3D shape reconstruction, and object recognition.

ELEC 548 - MACHINE LEARNING AND SIGNAL PROCESSING FOR NEUROENGINEERING
Short Title: NEURAL SIGNAL PROCESSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course covers advanced statistical signal processing and machine learning approaches for modern neuroscience data (primarily many-channel spike trains). Topics include latent variable models, point processes, Bayesian inference, dimensionality reduction, dynamical systems, and spectral analysis. Neuroscience applications include modeling neural firing rates, spike sorting, decoding. Cross-list: BIOL 548. Graduate/Undergraduate Equivalency: ELEC 483. Mutually Exclusive: Credit cannot be earned for ELEC 548 and ELEC 483.

ELEC 549 - COMPUTATIONAL PHOTOGRAPHY
Short Title: COMPUTATIONAL PHOTOGRAPHY
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Computational photography is an emerging field that aims to overcome the limitations of conventional digital imaging and display devices by using novel optics, signal processing and computer vision to perform more efficient and accurate measurement as well as produce more compelling and meaningful visualizations of the world around us. It is a convergence of many areas, such as optics, computer vision, computer graphics, image processing, photography, and so on. We will cover topics such as computational sensors with assorted pixel, mobile camera control, light field capture and rendering, computational flash photography, computational illumination for appearance acquisition and 3D reconstruction, reflectance transformation imaging, light transport analysis and novel displays.

ELEC 550 - ALGORITHMIC ROBOTICS
Short Title: ALGORITHMIC ROBOTICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): (COMP 221 or COMP 321) and COMP 215
Description: Robots have fascinated people for generations. Today, robots are built for applications as diverse as exploring remote planets, de-mining war zones, cleaning toxic waste, assembling cars, inspecting pipes in industrial plants and mowing lawns. Robots are also interacting with humans in a variety of ways: robots are museum guides, robots assist surgeon sin life threatening operations, and robotic cars can drive us around. The field of robotics studies not only the design of new mechanisms but also the development of artificial intelligence frameworks to make these mechanism useful in the physical world, integrating computer science, engineering, mathematics and more recently biology and sociology, in a unique way. This class will present fundamental algorithmic advances that enable today's robots to move in real environments and plan their actions. It will also explore fundamentals of the field of Artificial Intelligence through the prism of robotics. The class involves a significant programming project. Cross-list: COMP 550, MECH 550. Graduate/Undergraduate Equivalency: ELEC 450. Mutually Exclusive: Credit cannot be earned for ELEC 550 and ELEC 450.
ELEC 551 - DIGITAL COMMUNICATION
Short Title: DIGITAL COMMUNICATION
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Prerequisite(s): COMP 215 and (COMP 221 or COMP 321)
Description: Course in digital communications, designed to prepare students for engineering work in high-tech industries and for graduate work in communications, signal processing, and computer systems. Covers basic concepts and useful tools for design and performance analysis of transmitters and receivers in the physical layer of a communication system. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 430. Mutually Exclusive: Credit cannot be earned for ELEC 551 and ELEC 430.

ELEC 552 - OPERATING SYSTEMS AND CONCURRENT PROGRAMMING
Short Title: OP SYS/CONCURRENT PROGRAMMING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate

ELEC 553 - MOBILE AND EMBEDDED SYSTEM DESIGN AND APPLICATION
Short Title: MOBILE & EMBEDDED SYSTEM
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: ELEC 553 introduces mobile and embedded system design and applications to students and provides them hands-on design experience. It consists of three interlearning parts: lectures, student project, and student presentations. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 424. Mutually Exclusive: Credit cannot be earned for ELEC 553 and ELEC 424.
Course URL: www.ruf.rice.edu/~mobile/elec424/

ELEC 554 - COMPUTER SYSTEMS ARCHITECTURE
Short Title: COMPUTER SYSTEMS ARCHITECTURE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Evolution of key architecture concepts found in advanced uniprocessor systems. Fundamental and advanced pipelining techniques and associated issues for improving processor performance. Illustrated with RISC processors such as the ARM processor. Examine several metrics for processor performance, such as Amdahl’s law. Key concepts of data and program memory systems found in modern systems with memory hierarchies and caches. Perform experiments in cache performance analysis. Influence of technology trends, such as Moore’s law, on processor implementation Approaches for exploiting instruction level parallelism, such as VLIW. Introduction to parallel and multicore architectures. Introduction to processor architectures targeted for imbedded applications. Additional coursework required beyond the undergraduate course requirements. Cross-list: COMP 554. Graduate/Undergraduate Equivalency: ELEC 425. Mutually Exclusive: Credit cannot be earned for ELEC 554 and ELEC 425.

ELEC 555 - ADVANCED DIGITAL HARDWARE DESIGN, IMPLEMENTATION, AND OPTIMIZATION
Short Title: ADV DIGITAL DESIGN & IMPLEMENT
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This graduate level course will investigate design and implementation of modern digital signal processing, machine learning, and security algorithms in hardware (including FPGAs and ASICs). Along with learning the principals of design, students will acquire hands-on experience in hardware implementation and the use of the hardware in modern applications including but not limited to mobile phones, biomedical devices, and smart cards. Emphasis is on digital processors, design implementation on FPGA/ASIC fabrics and testing real systems on board, architectures, control, functional units, and circuit topologies for increased performance and reduced circuit size and power dissipation. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 427. Mutually Exclusive: Credit cannot be earned for ELEC 555 and ELEC 427. Repeatable for Credit.
ELEC 557 - ARTIFICIAL INTELLIGENCE
Short Title: ARTIFICIAL INTELLIGENCE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): COMP 221 or COMP 321
Description: This is a foundational course in artificial intelligence, the discipline of designing intelligent agents. The course will cover the design and analysis of agents that do the right thing in the face of limited information and computational resources. The course revolves around two main questions: how agents decide what to do, and how they learn from experience. Tools from computer science, probability theory, and game theory will be used. Interesting examples of intelligent agents will be covered, including poker playing programs, bots for various games (e.g. WoW), DS1 – the spacecraft that performed an autonomous flyby of Comet Borrely in 2001, Stanley -- the Stanford robot car that won the Darpa Grand Challenge, Google Maps and how it calculates driving directions, face and handwriting recognizers, Fedex package delivery planners, airline fare prediction sites, and fraud detectors in financial transactions. Additional coursework required beyond the undergraduate course requirements. Cross-list: COMP 556. Graduate/Undergraduate Equivalency: ELEC 429. Mutually Exclusive: Credit cannot be earned for ELEC 556 and ELEC 429.
Course URL: www.owl.net.rice.edu/~comp440

ELEC 558 - DIGITAL SIGNAL PROCESSING
Short Title: DIGITAL SIGNAL PROCESSING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Methods for analysis of discrete-time signals and design of discrete-time systems including topics of: discrete-time linear systems, difference equations, z-transforms, discrete convolution, stability, discrete-time Fourier transforms, analog-to-digital and digital-to-analog conversion, digital filter design, discrete Fourier transforms, fast Fourier transforms, multi-rate signal processing, filter banks, and spectral analysis. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 431. Mutually Exclusive: Credit cannot be earned for ELEC 558 and ELEC 431.

ELEC 559 - INNOVATION LAB FOR MOBILE HEALTH
Short Title: INNOVATION LAB - MOBILE HEALTH
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will be an innovation lab for mobile health products. The students will organize themselves in groups with complementary skills and work on a single project for the whole semester. The aim will be to develop a product prototype which can then be demonstrated to both medical practitioners and potential investors. For successful projects with an operational prototype, the next steps could be applying for OWLspark (Rice accelerator program) or crowd sourcing (like Kickstarter) and/or work in Scalable Health Labs over summer. ELEC Juniors can also continue the project outcomes as a starting point for their senior design. Additional course work required beyond the undergraduate course requirements. Cross-list: BIOE 534. Graduate/Undergraduate Equivalency: ELEC 419. Mutually Exclusive: Credit cannot be earned for ELEC 559 and ELEC 419. Repeatable for Credit.
Course URL: www.ece.rice.edu/~ashu/ELEC419.html

ELEC 560 - PHYSICS OF SENSOR MATERIALS AND NANOSENSOR TECHNOLOGY
Short Title: PHYSICS OF SENSORS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topics covered include MEMS, MOEMS, and NEMS systems along with special materials such as liquid crystals, piezoelectrics, memory metal, and topological insulators. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 460. Mutually Exclusive: Credit cannot be earned for ELEC 560 and ELEC 460.
ELEC 561 - OPTICAL TECHNIQUES FOR IMAGING THROUGH SCATTERING MEDIA  
Short Title: IMAGING THROUGH SCATTERS  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Topics covered include basics of Physical optics, and Fourier optics with a strong emphasis on its applications to imaging through scattering media.

ELEC 562 - OPTOELECTRONIC DEVICES  
Short Title: OPTOELECTRONIC DEVICES  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: This course provides an introduction to the fundamental principles of semiconductor optoelectronic devices. After reviewing the basic elements of quantum mechanics of electrons and photons, light-matter interaction (including laser oscillations), and semiconductor physics (band structure, heterostructures and alloys, optical processes), we will study the details of modern semiconductor devices for the generation, detection, and modulation of light. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 462. Mutually Exclusive: Credit cannot be earned for ELEC 562 and ELEC 462.

ELEC 563 - INTRODUCTION TO SOLID STATE PHYSICS I  
Short Title: INTRO TO SOLID STATE PHYSICS I  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Fundamental concepts of crystalline solids, including crystal structure, band theory of electrons, and lattice vibration theory. Cross-list: PHYS 563.

ELEC 564 - SOLID-STATE PHYSICS II  
Short Title: INTRO SOLID STATE PHYSICS II  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Continuation of PHYS 563, including scattering of waves by crystals, transport theory, and magnetic phenomena. Cross-list: PHYS 564.

ELEC 565 - MATERIALS FOR ENERGY AND PHOTOCATALYSIS  
Short Title: MATERIALS FOR ENERGY&CATALYSIS  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: This course will cover the basic physics and chemistry of solar energy conversion and storage devices, and the current state of the art and future challenges in materials for energy and photocatalysis. In addition, physical and chemical characterization techniques will be covered.

ELEC 566 - NANOPHOTONICS AND METAMATERIALS  
Short Title: NANOPHOTONICS & METAMATERIALS  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: The course will discuss basic concepts of nanophotonics and focus on what metamaterials are, how they work and how to build them. The course will conclude with applications of various meta-devices and upcoming research topics.

ELEC 567 - NANO-OPTICS  
Short Title: NANO-OPTICS  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: The goal of this course is to understand concepts of light localization and light-matter interactions on the nanoscale, and to familiarize the students with the state-of-the-art research in the field of nano-optics.

ELEC 568 - LASER SPECTROSCOPY  
Short Title: LASER SPECTROSCOPY  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Introduction to the theory and practice of laser spectroscopy as applied to atomic and molecular systems. The course covers fundamentals of spectroscopy, lasers and spectroscopic light sources, high resolution and time resolved laser spectroscopy with applications in atmospheric chemistry, environmental science and medicine. Repeatable for Credit.
ELEC 569 - ULTRAFAST OPTICAL PHENOMENA
Short Title: ULTRAFAST OPTICAL PHENOMENA
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course covers the generation, propagation, and measurement of short laser pulses, of duration less than one picosecond. Concepts include mode locking, the effects of dispersion, optical pulse amplification, and time-domain non-linear optical phenomena. Intended as an introduction to ultrafast phenomena for graduate students or advanced undergraduates; a basic understanding of electromagnetic waves and of quantum mechanics is assumed. Cross-list: PHYS 569.
Course URL: www.ece.rice.edu/~daniel/569/569files.html

ELEC 571 - IMAGING AT THE NANOSCALE
Short Title: IMAGING AT THE NANOSCALE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A survey of the techniques used in imaging micron and nanometer structures with an emphasis on applications in chemistry, physics, biology, and engineering. The course includes an introduction to scanning probe, submicron optical, and electron microscopies, as well as discussions on the fundamental and practical aspects of image acquisition, artifacts, filtering, and machine learning analysis of such data. Homeworks will involve some familiarity and proficiency with Matlab. The final project will include analysis of the student’s own research data.

ELEC 572 - FINITE ELEMENT METHOD FOR MULTIPHYSICS MODELING
Short Title: MULTIPHYSICS MODELING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will provide a hands-on experience on the modeling of micro and nano systems based on the mutual interaction among different physical phenomena. COMSOL Multiphysics, based on the Finite Element Method (FEM), will be utilized as flexible modeling tool to learn how to design a wide range of devices or describe coupled physical mechanisms including electromagnetic waves, heat transfer, fluid dynamics and mass transport. The course will focus in particular on the interaction between light and nanomaterials and how electromagnetic heat dissipation can play a major role in different applications Recommended Prerequisite(s): Basic electromagnetism and basic calculus

ELEC 573 - NETWORK SCIENCE AND ANALYTICS
Short Title: NETWORK SCIENCE AND ANALYTICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides an introduction to complex networks, their structure, and function, with examples from engineering, biology, and social sciences. Topics include spectral graph theory, notions of centrality, community detection, random graph models, inference in networks, opinion dynamics, and contagion phenomena. Our main goal is to study network structures and how they can be leveraged to better understand data defined on them. Recommended Prerequisite(s): Linear algebra, probability and statistics, and basic ability to program in Python.

ELEC 574 - UBQ AND WEARABLE COMPUTING
Short Title: UBQ AND WEARABLE COMPUTING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Wireless and mobile computing, affordable sensors and interaction devices being woven into our daily life and invisible, has created boundless opportunities for in-the-world computing applications that can transform our lives. This course will introduce students to the field of Ubiquitous and Wearable Computing -- a multidisciplinary research area that draws from sensors, machine learning, signal processing, as well as human computer interaction. This class combines lectures, hands-on exercises and assignments, reading state of the art research papers, class discussions and a final project.

ELEC 575 - LEARNING FROM SENSOR DATA
Short Title: LEARNING FROM SENSOR DATA
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The first half of this course develops the basic machine learning tools for signals images, and other data acquired from sensors. Tools covered include principal components analysis, regression, support vector machines, neural networks, and deep learning. The second half of this course overviews a number of applications of sensor data science in neuroscience, image and video processing, and machine vision. Additional course work required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 475. Mutually Exclusive: Credit cannot be earned for ELEC 575 and ELEC 475. Repeatable for Credit.
ELEC 576 - A PRACTICAL INTRODUCTION TO DEEP MACHINE LEARNING
Short Title: INTRODUCTION TO DEEP LEARNING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Deep Machine Learning has recently made many advances in difficult perceptual tasks, including object and phoneme recognition, and natural language processing. However, the field has a steep learning curve, both conceptually and practically. The point of this course is to engage students by jumping into the deep end, and building their own architectures and algorithms. Cross-list: COMP 576.

ELEC 577 - ALGORITHMS AND OPTIMIZATION FOR DATA SCIENCE
Short Title: OPTIMIZATION FOR DATA SCIENCE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: In this course, we study algorithms for analyzing data with provable performance, statistical, and computational guarantees. We focus on applications in machine learning and signal processing. Topics include: efficient algorithms for convex optimization, inverse problem, low-rank and sparse models, dimensionality reduction, and randomized algorithms. Recommended Prerequisite(s): MATH 355 and (ECON 307 or STAT 310) or digital circuit courses.

ELEC 578 - INTRODUCTION TO MACHINE LEARNING
Short Title: INTRO TO MACHINE LEARNING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course provides an introduction to concepts, methods, best practices, and theoretical foundations of machine learning. Topics covered include regression, classification, kernels, clustering, decision trees, ensemble learning, empirical risk minimization and regularization, and learning theory. Additional work is required for graduate students beyond the undergrad requirement. Graduate/Undergraduate Equivalency: ELEC 478. Mutually Exclusive: Credit cannot be earned for ELEC 578 and DSCI 303.

ELEC 581 - CARDIOVASCULAR AND RESPIRATORY SYSTEM DYNAMICS
Short Title: CARDIO - RESP SYSTEM DYNAMICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Autonomic nervous system control of the cardiovascular and respiratory systems. Development of models of neuron and cardiac cell activity; models of ventricular and vascular system mechanics; models of pulmonary mechanics and gas transport. Includes a study of instrumentation and techniques used in the cardiac catheterization laboratory. Discussions of different types of ventricular assist devices is also included. The course serves as an introduction to engineering in cardiovascular and respiratory system diagnosis and critical care medicine. Cross-list: BIOE 581. Recommended Prerequisite(s): Knowledge of ordinary differential equations; electricity and magnetism, and solid mechanics form elementary physics; linear control theory and elementary physiology of the cardiovascular and respiratory systems.

ELEC 582 - PHYSIOLOGICAL CONTROL SYSTEMS
Short Title: PHYSIOLOGICAL CONTROL SYSTEMS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A study of the somatic and autonomic nervous system control of biological systems. Simulation methods, as well as, techniques common to linear and nonlinear control theory are used. Also included is an introduction to sensors and instrumentation techniques. Examples are taken from the cardiovascular, respiratory, and visual systems. Additional coursework required beyond the undergrad course requirements. Cross-list: BIOE 582. Graduate/Undergraduate Equivalency: ELEC 482. Mutually Exclusive: Credit cannot be earned for ELEC 582 and ELEC 482.

ELEC 583 - COMPUTATIONAL NEUROSCIENCE AND NEURAL ENGINEERING
Short Title: COMP/NEUROSCIENCE/NEURAL ENGR
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: An introduction to the anatomy and physiology of the brain. Includes basic electrophysiology of nerve and muscle. Develops mathematical models of neurons, synaptic transmission and natural neural networks. Leads to a discussion of neuromorphic circuits which can represent neuron and neural network behavior in silicon. Recommendation: Knowledge of electrical circuits, operational amplifier circuits and ordinary differential equations. Involves programming Matlab. Cross-list: BIOE 583, NEUR 583. Graduate/Undergraduate Equivalency: ELEC 481. Recommended Prerequisite(s): Knowledge of basic electrical and operational amplifier circuits; and ordinary differential equations. Mutually Exclusive: Credit cannot be earned for ELEC 583 and ELEC 481.
ELEC 584 - FUNDAMENTALS OF HUMAN NEUROIMAGING
Short Title: HUMAN NEUROIMAGING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A survey of methods and results for human brain imaging. Describes the physical and physiological mechanisms of image acquisition, formation and processing of several medical imaging modalities such as X-ray, CT, MRI, and US that are used to evaluate the human anatomy. The course also includes visits to a clinical site to gain experience with the various imaging modalities covered in class. Additional coursework required beyond the undergraduate course requirements. Cross-list: BIOE 591. Graduate/Undergraduate Equivalency: ELEC 484. Mutually Exclusive: Credit cannot be earned for ELEC 584 and ELEC 484.

ELEC 585 - FUNDAMENTALS OF MEDICAL IMAGING I
Short Title: FUND MEDICAL IMAGING I
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will introduce basic principles of image acquisition, formation and processing of several medical imaging modalities such as PET, optical, and EEG/MEG source localization. Course taught at Baylor College of Medicine. Cross-list: NEUR 584. Graduate/Undergraduate Equivalency: ELEC 484. Mutually Exclusive: Credit cannot be earned for ELEC 584 and ELEC 484.

ELEC 586 - FUNDAMENTALS OF MEDICAL IMAGING II
Short Title: FUND MEDICAL IMAGING II
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course focuses on functional imaging modalities used specifically in nuclear medicine such as Gamma cameras, SPECT, and PET imaging. The course will introduce the basic principles of image acquisition, formation, processing and the clinical applications of these imaging modalities and lays the foundations for understanding the principles of radiotracer kinetic modeling. A trip to a clinical site in also planned to gain experience with nuclear medicine imaging. Additional coursework required beyond the undergraduate course requirements. Cross-list: BIOE 596. Graduate/Undergraduate Equivalency: ELEC 486. Mutually Exclusive: Credit cannot be earned for ELEC 586 and ELEC 486.

ELEC 587 - INTRODUCTION TO NEUROENGINEERING: MEASURING AND MANIPULATING NEURAL ACTIVITY
Short Title: INTRO TO NEUROENGINEERING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will serve as an introduction to quantitative modeling of neural activity and the methods used to stimulate and record brain activity. Additional coursework required beyond the undergraduate course requirements. Graduate/Undergraduate Equivalency: ELEC 380. Mutually Exclusive: Credit cannot be earned for ELEC 587 and BIOE 480/BIOE 590/ELEC 380/ELEC 480/ELEC 580.

ELEC 588 - THEORETICAL NEUROSCIENCE I: BIOPHYSICAL MODELING OF CELLS AND CIRCUITS
Short Title: THEORETICAL NEUROSCIENCE
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: We present the theoretical foundations of cellular and systems neuroscience from distinctly quantitative point of view. We develop the mathematical and computational tools as they are needed to model, analyze, visualize and interpret a broad range of experimental data. Additional course work required beyond the undergraduate course requirements. Cross-list: CAAM 615, NEUR 615. Graduate/Undergraduate Equivalency: ELEC 488. Mutually Exclusive: Credit cannot be earned for ELEC 588 and ELEC 488.

ELEC 589 - NEURAL COMPUTATION
Short Title: NEURAL COMPUTATION
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: How does the brain work? Understanding the brain requires sophisticated theories to make sense of the collective actions of billions of neurons and trillions of synapses. Word theories are not enough; we need mathematical theories. The goal of this course is to provide an introduction to the mathematical theories of learning and computation by neural systems. These theories use concepts from dynamical systems (attractors, oscillations, chaos) and concepts from statistics (information, uncertainty, inference) to relate the dynamics and functions of neural networks. We will apply these theories to sensory computation, learning and memory, and motor control. Students will learn to formalize and mathematically answer questions about neural computations, including "what does a network compute?", "how does it compute?", and "why does it compute that way?" Prerequisites: knowledge of calculus, linear algebra, and probability and statistics. Graduate/Undergraduate Equivalency: ELEC 489. Mutually Exclusive: Credit cannot be earned for ELEC 589 and ELEC 489.
ELEC 590 - GRADUATE NON-THESIS RESEARCH PROJECTS
Short Title: GR NON-THESIS RES PROJECTS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Theoretical and experimental investigations under staff direction. Instructor Permission Required. Repeatable for Credit.

ELEC 591 - GRADUATE ELECTRICAL ENGINEERING RESEARCH PROJECTS - VERTICALLY INTEGRATED PROJECTS
Short Title: GR ELEC ENG'G RESEARCH VIP
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Vertically Integrated Projects (VIP) teams include students from multiple years working on one larger, multi-year project defined by the instructor. Instructor Permission Required. Graduate/Undergraduate Equivalency: ELEC 491. Mutually Exclusive: Credit cannot be earned for ELEC 591 and ELEC 491. Repeatable for Credit.

ELEC 598 - INTRODUCTION TO ROBOTICS
Short Title: INTRODUCTION TO ROBOTICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to the kinematics, dynamics, and control of robot manipulators and to applications of artificial intelligence and computer vision in robotics. Additional work required for Graduate course. Cross-list: COMP 598, MECH 598. Graduate/Undergraduate Equivalency: ELEC 498. Mutually Exclusive: Credit cannot be earned for ELEC 598 and ELEC 498.

ELEC 599 - FIRST YEAR GRADUATE STUDENT PROJECTS
Short Title: 1ST YEAR GRAD STUDENTS PROJECT
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 6
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Supervised project required of all first-year graduate students in the Ph.D. program.
ELEC 631 - ADVANCED TOPICS IN SIGNAL PROCESSING AND MACHINE LEARNING
Short Title: TOPICS-SIGNAL PROCESSING & ML
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): ELEC 531 and ELEC 533
Description: There is a long history of algorithmic development for solving inferential and estimation problems that play a central role in a variety of learning, sensing, and processing systems, including medical imaging scanners, numerous machine learning algorithms, and compressive sensing, to name just a few. Until recently, most algorithms for solving inferential and estimation problems have iteratively applied static models derived from physics or intuition. In this course, we will explore a new approach that is based on “learning” various elements of the problem including i) stepsizes and parameters of iterative algorithms, ii) regularizers, and iii) inverse functions. For example, we will explore a new approach for solving inverse problems that is based on transforming an iterative, physics-based algorithm into a deep network whose parameters can be learned from training data. For a range of different inverse problems, deep networks have been shown to offer faster convergence to a better quality solution. Specific topics to be discussed include: Ill-posed inverse problems, iterative optimization, deep learning, neural networks, learning regularizers. This is a “reading course,” meaning that students will read and present classic and recent papers from the technical literature to the rest of the class in a lively debate format. Discussions will aim at identifying common themes and important trends in the field. Students will also get hands on experience with optimization problems and deep learning software through a group project. Repeatable for Credit.

ELEC 632 - ADVANCED TOPICS IN IMAGE AND VIDEO PROCESSING
Short Title: ADV TOPIC IMAGE&VIDEO PROCESS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Seminar on topics of current research interest in image and video processing. Students participate in selecting and presenting papers from technical literature. Discussions aim at identifying common themes and important trends in the field.

ELEC 635 - NETWORK INFORMATION THEORY
Short Title: NETWORK INFORMATION THEORY
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): ELEC 535
Description: This course will introduce the key building blocks in network information theory: multiple access, broadcast, relay and interference channels. Further topics will be explored as part of projects.

ELEC 677 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Lecture/Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

ELEC 680 - NANO-NEUROTECHNOLOGY
Short Title: NANO-NEUROTECHNOLOGY
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will review current nanofabricated technologies for measuring, manipulating, and controlling neural activity. The course will be based on reviewing current academic literature and topics will include nano-electronic, -photonic, -mechanical, and -fluidic neural devices. Cross-list: BIOE 680.

ELEC 681 - FUNDAMENTALS OF MACHINE LEARNING
Short Title: FUNDAMENTALS MACHINE LEARNING
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course examines the fundamentals of machine learning, including supervised learning, unsupervised learning, and reinforcement learning. This course will provide the student with the formal concepts and the basic intuition for the different topics of machine learning, from artificial neural networks to value function approximation. Because of the shared problems of machine learning, statistical inference, and signal processing, a focus of the course will be on share solution, e.g., dimensionality reduction, of these three fields. Repeatable for Credit.

ELEC 689 - NANOPHOTONICS, SPECTROSCOPY, AND MATERIALS FOR SUSTAINABILITY
Short Title: NANOPHOT, SPECT, MAT4SUST
Department: Electrical & Computer Eng.
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This seminar will cover the contributions that nanophotonic concepts and advanced spectroscopy techniques can make to the development and characterization of novel materials for energy and sustainability. We will cover nanophotonic concepts for novel materials and characterization techniques, ultrafast and nanoscale spectroscopy techniques, and applications in energy and sustainability. Repeatable for Credit.
ELEC 692 - ADVANCED TOPICS IN DISTRIBUTED SYSTEMS  
Short Title: ADV TOPICS IN DISTRIBUTED SYST  
Department: Electrical & Computer Eng.  
Grade Mode: Satisfactory/Unsatisfactory  
Course Type: Seminar  
Credit Hours: 1-3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: We will learn about and discuss recent advances in various areas in computer systems, including topics on security, distributed systems, networking, operating systems, and databases. The seminar will be divided into several sections, with each section focusing on one research trend. In each class, students will read one classic paper on the topic, and present two recent papers that describe the state of the art. Students can also team up and do a semester-long research project on any relevant topics. All students will need to make a final presentation at the end of the class on a potential project idea; for students that choose to do a semester-long project, they will also submit a six-page report on their project, in addition to giving a final presentation. Instructor Permission Required. Cross-list: COMP 645. Repeatable for Credit.

ELEC 693 - ADVANCED TOPICS-COMPUTER SYSTEMS  
Short Title: ADV TOPICS - COMPUTER SYSTEMS  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Seminar  
Credit Hours: 1-3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: This course is a discussion based seminar about state of the art embedded and digital signal processing systems, with emphasis on both hardware architectures as well as software tools, programming models, and compilers. The seminar focuses on state of the art academic and commercial offerings in these areas. Cross-list: COMP 693. Repeatable for Credit.

ELEC 694 - HOW TO BE A CHIEF TECHNOLOGY OFFICER  
Short Title: HOW TO BE A CTO  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Seminar  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Survey of the component and standards trends that are the basis of personal computers and digital appliances with the aim of predicting technologies, solutions, and new products five years into the future. Examples of these technologies are dual Core processors, iPods and their evolution, mobile wireless data devices, and even Google vs. Microsoft. Students will each pick a topic important to the digital lifestyle and through a series of one-on-one sessions develop a depth of understanding that is presented to the class. Formerly "Future Personal Computing Technologies." Cross-list: COMP 694. Repeatable for Credit.  
Course URL: www.ece.rice.edu/Courses/694/  

ELEC 695 - ADVANCED TOPICS IN COMMUNICATIONS AND STATISTICAL SIGNAL PROCESSING  
Short Title: INNOVATIONS IN MOBILE HEALTH  
Department: Electrical & Computer Eng.  
Grade Mode: Standard Letter  
Course Type: Seminar  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Section 1: - Innovations in Mobile Health - In this seminar, we will study the merging area of mobile health, enabled by prevalent data connectivity, highly portable medical sensors, smart-phones and inexpensive cloud computing. The seminar will involve a mix of lectures, paper reading, case studies and group projects. The course is suitable for both undergraduate (junior and seniors) and graduate students. The course is part of the new ECE initiative on scalable health (http://sh.rice.edu). Open to both undergraduate and graduate students. Section 2: - This is a graduate seminar class focused on the role of information theory in engineering wireless networks. Students will survey, read, and present both classic as well as recent papers in the area. Repeatable for Credit.

ELEC 698 - ECE PROFESSIONAL MASTERS SEMINAR SERIES  
Short Title: ECE PROFESSIONAL MASTER SEM  
Department: Electrical & Computer Eng.  
Grade Mode: Satisfactory/Unsatisfactory  
Course Type: Seminar  
Credit Hour: 1  
Restrictions: Enrollment is limited to Graduate level students. Enrollment limited to students in a Master of Electrical Eng degree.  
Course Level: Graduate  
Description: The Professional Masters Seminar Series presents a combination of seminars on emerging research topics in the many areas of ECE and industry-focused professional development. This course includes attendance and reports based on the seminars, colloquia, and distinguished lectures held each semester. Repeatable for Credit.

ELEC 699 - FRONTIERS OF ELECTRICAL AND COMPUTER ENGINEERING  
Short Title: FRONTIERS OF ECE  
Department: Electrical & Computer Eng.  
Grade Mode: Satisfactory/Unsatisfactory  
Course Type: Seminar  
Credit Hour: 1  
Restrictions: Enrollment is limited to students with a major in Electrical & Computer Eng.. Enrollment is limited to Graduate level students. Enrollment limited to students in a Doctor of Philosophy or Master of Electrical Eng degrees.  
Course Level: Graduate  
Description: Frontiers of Electrical and Computer Engineering presents emerging research topics in the many areas of ECE. This course includes attendance and reports based on the seminars, colloquia, and distinguished lectures held each semester. Repeatable for Credit.

ELEC 800 - RESEARCH AND THESIS  
Short Title: RESEARCH AND THESIS  
Department: Electrical & Computer Eng.  
Grade Mode: Satisfactory/Unsatisfactory  
Course Type: Research  
Credit Hours: 1-15  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Repeatable for Credit.  
