**ELECTRICAL ENGINEERING (EENG)**

**EENG 101b, The Digital Information Age**  Priya Panda  
An introduction to machine learning for communicating between humans and digital systems. Each student generates data by speaking the ten English digits 0 through 9 into the microphone of a laptop. Programs written in the popular engineering programming language Matlab convert the microphone speech into numerical features that are then processed to have the computer classify the speech sounds into their digit values. The course covers the ideas of template matching and neural networks for digit speech classification. The initial programs are written by the instructor and students modify them with the help of the instructor to accomplish a student-selected task. Intended for students in the humanities and social sciences interested in machine learning and for first-year students considering a major in electrical engineering. A familiarity with any programming language and matrix algebra is helpful. Priority given to non-science majors and first-year students interested in electrical engineering.  QR

**EENG 200a, Introduction to Electronics**  Mark Reed  
Introduction to the basic principles of analog and digital electronics. Analysis, design, and synthesis of electronic circuits and systems. Includes a team-oriented design project for real-world applications, such as a high-power stereo amplifier design. Electronics design of analog circuits for particular functions and specifications, in actual applications wherever possible, using design-oriented models for active devices; single-ended and differential amplifiers; current sources and active loads; operational amplifiers; feedback. Prerequisite: EENG 200.

**EENG 200b, Introduction to Computer Engineering**  Priya Panda  
Introduction to design in a laboratory setting. A wide variety of practical systems are designed and implemented to exemplify the basic principles of systems theory. Topics include data representation in digital form, combinational logic design and Boolean algebra, sequential logic design and finite state machines, and basic computer architecture principles. Hands-on laboratory involving the active design, construction, and programming of a simple processor.  QR

**EENG 202a, Communications, Computation, and Control**  Wenjun Hu  
Introduction to systems that sense, process, control, and communicate. Topics include information theory and coding (compression, channel coding); network systems (network architecture, routing, wireless networks); signals and systems (linear systems, Fourier techniques, bandlimited sampling); estimation and learning (hypothesis testing, regression, classification); and end-to-end application examples (security, communication systems). MATLAB programming assignments illustrate concepts. Students should have basic familiarity with counting (combinatorics), probability and statistics (independence between events, conditional probability, expectation of random variables, uniform distribution). Prerequisite: MATH 115. AP Stats preferred.  QR

**EENG 202b, Circuits and Systems Design**  Hongxing Tang  
Introduction to design in a laboratory setting. A wide variety of practical systems are designed and implemented to exemplify the basic principles of systems theory. Systems include audio filters and equalizers, electrical and electromechanical feedback systems, radio transmitters and receivers, and circuits for sampling and reconstructing music. Prerequisites: EENG 200  QR, SC

* EENG 235a and EENG 236b, Special Projects  Mark Reed  
Faculty-supervised individual or small-group projects with emphasis on laboratory experience, engineering design, or tutorial study. Students are expected to consult the director of undergraduate studies and appropriate faculty members about ideas and suggestions for suitable topics during the term preceding enrollment. These courses may be taken at any time during the student’s career. Enrollment requires permission of both the instructor and the director of undergraduate studies, and submission to the latter of a one- to two-page prospectus signed by the instructor. The prospectus is due in the departmental office one day prior to the date that the student’s course schedule is due. ½ Course cr per term

**EENG 310b, Signals and Systems**  A Stephen Morse  
Concepts for the analysis of continuous and discrete-time signals including time series. Techniques for modeling continuous and discrete-time linear dynamical systems including linear recursions, difference equations, and shift sequences. Topics include continuous and discrete Fourier analysis, Laplace and Z transforms, convolution, sampling, data smoothing, and filtering. Prerequisite: MATH 115. Recommended preparation: EENG 202.  QR

**EENG 320a / PHY 320a, Introduction to Semiconductor Devices**  Hongxing Tang  
An introduction to the physics of semiconductors and semiconductor devices. Topics include crystal structure; energy bands in solids; charge carriers with their statistics and dynamics; junctions, p-n diodes, and LEDs; bipolar and field-effect transistors; and device fabrication. Additional lab one afternoon per week. Prepares for EENG 325 and 401. Recommended preparation: EENG 200. PHYS 180 and 181 or permission of instructor  QR, SC

**EENG 325a, Electronic Circuits**  Fengnian Xia  
Models for active devices; single-ended and differential amplifiers; current sources and active loads; operational amplifiers; feedback; design of analog circuits for particular functions and specifications, in actual applications wherever possible, using design-oriented methods. Includes a team-oriented design project for real-world applications, such as a high-power stereo amplifier design. Electronics Workbench is used as a tool in computer-aided design. Additional lab one afternoon per week. Prerequisite: EENG 200.  QR, RP
EENG 348b / CPSC 338b, Digital Systems  Rajit Manohar
Development of engineering skills through the design and analysis of digital logic components and circuits. Introduction to gate-level circuit design, beginning with single gates and building up to complex systems. Hands-on experience with circuit design using computer-aided design tools and microcontroller programming. Recommended preparation: EENG 201.  QR

EENG 397a / ENAS 397a, Mathematical Methods in Engineering  J Rimas Vaisnys
Exploration of several areas of mathematics useful in science and engineering; recent approaches to problem solving made possible by developments in computer software. Mathematica and Eureqa are used to investigate and solve problems involving nonlinear differential equations, complex functions, and partial differential equations. Prerequisites: MATH 222, and ENAS 194 or MATH 246, or equivalents; familiarity with computer programming.  QR

EENG 400b, Electronic Materials  Jung Han
Survey and review of fundamental material issues pertinent to modern microelectronic and optoelectronic technology. Topics include band theory, electronic transport, surface kinetics, diffusion, defects in crystals, thin film elasticity, crystal growth, and heteroepitaxy. Formerly EENG 408. Prerequisite: EENG 320 or permission of instructor.  QR, SC

EENG 401a, Photonics and Optical Electronics  Jung Han
A survey of the enabling components and devices that constitute modern optical communication systems. Focus on the physics and principles of each functional unit, its current technological status, design issues relevant to overall performance, and future directions. Formerly EENG 410. EENG 320 and APHY 322, or permission of instructor  QR, SC

EENG 402b / APHY 418b, Advanced Electron Devices  Mark Reed
The science and technology of semiconductor electron devices. Topics include compound semiconductor material properties and growth techniques; heterojunction, quantum well and superlattice devices; quantum transport; graphene and other 2D material systems. Formerly EENG 418. Prerequisite: EENG 320 or equivalent.  QR, SC

EENG 403b / APHY 321b, Semiconductor Silicon Devices and Technology  Tso-Ping Ma
Introduction to integrated circuit technology, theory of semiconductor devices, and principles of device design and fabrication. Laboratory involves the fabrication and analysis of semiconductor devices, including Ohmic contacts, Schottky diodes, p-n junctions, solar cells, MOS capacitors, MOSFETs, and integrated circuits. Formerly EENG 401. Prerequisite: EENG 320 or equivalent or permission of instructor.  QR, SC

* EENG 408a, Emerging CMOS Technology and Beyond  Tso-Ping Ma
This is a “seminar” style course that introduces to students various contemporary topics in emerging CMOS science and technology. Possible topics include Post-Moore’s law alternatives, artificial intelligence, neuromorphic computing, quantum computers, emerging memories, and other topics of interest to students. In addition to the instructor, students hear from and interact with world’s renowned guest lecturers during and after the regular class hours. Prerequisite: EENG 320 or equivalent, or permission by instructor.

* EENG 425a, Introduction to VLSI System Design  Richard Lethin
Chip design; integrated devices, circuits, and digital subsystems needed for design and implementation of silicon logic chips. CMOS fabrication overview, complementary logic circuits, design methodology, computer-aided design techniques, timing, and area estimation. Exploration of recent and future chip technologies. A course project is the design, through layout, of a digital CMOS subsystem chip; selected projects are fabricated for students. Prerequisite: familiarity with computer programming and with circuits at the level of introductory physics.  QR

EENG 431a, Foundations of Data Science  Amin Karbasi
Recent advances in data science have enabled us to make tremendous progress in various fields including robotics, machine learning, computer vision, medicine, etc. This course provides an easy, yet rigorous, introduction to the mathematical and algorithmic foundations of data science. We cover key ideas that have led to such progress from statistics to optimization. The course is organized around three themes: What is learning? What algorithms we can use to learn? How can we optimize resources for efficient learning? Prerequisites: MATH 120, MATH 222, CPSC 365, and STAT 241. SC

* EENG 432a / AMTH 342a, Linear Systems  A Stephen Morse
Introduction to finite-dimensional, continuous, and discrete-time linear dynamical systems. Exploration of the basic properties and mathematical structure of the linear systems used for modeling dynamical processes in robotics, signal and image processing, economics, statistics, environmental and biomedical engineering, and control theory. Prerequisite: MATH 222 or permission of instructor.  QR

EENG 434b / MATH 251b / S&DS 351b, Stochastic Processes  Joseph Chang
Introduction to the study of random processes including linear prediction and Kalman filtering, Poisson counting process and renewal processes, Markov chains, branching processes, birth-death processes, Markov random fields, martingales, and random walks. Applications chosen from communications, networking, image reconstruction, Bayesian statistics, finance, probabilistic analysis of algorithms, and genetics and evolution. Prerequisite: S&DS 241 or equivalent. QR

* EENG 438b, Neural Networks for Pattern Recognition, Identification, and Control  Kumpati Narendra
Design of artificial neural networks (ANN) for approximation, pattern recognition, identification, and control. Introduction to the theory of artificial neural networks and linear adaptive control; adaptive identification and control problems in nonlinear dynamical systems. Applications in engineering and biology. Prerequisite: EENG 436 or permission of instructor.  QR
EENG 439a, Neural Networks and Learning Systems  Priya Panda
Neural networks (NNs) have become all-pervasive giving us self-driving cars, Siri Voice assistants, Alexa, and much more. While deep NNs deliver state-of-the-art accuracy on many artificial intelligence tasks, it comes at the cost of high computational complexity. Accordingly, designing efficient hardware architectures for deep neural networks is an important step towards enabling the wide deployment of NNs, particularly in low-power computing platforms, such as, mobiles, embedded Internet of Things (IoT) and drones. This course aims to provide a thorough overview on deep learning techniques, while highlighting the key trends and advances toward efficient processing of deep learning in hardware systems, considering algorithm-hardware co-design techniques. Prerequisites: MATH 222 or CPSC 202, EENG 201, and knowledge of Python programming.

EENG 445a / BENG 445a, Biomedical Image Processing and Analysis  James Duncan and Lawrence Staib
This course is an introduction to biomedical image processing and analysis, covering image processing basics and techniques for image enhancement, feature extraction, compression, segmentation, registration and motion analysis including traditional and machine learning techniques. Student learn the fundamentals behind image processing and analysis and algorithms and methods with an emphasis on biomedical applications. Prerequisite: BENG 242 or EENG 310 or permission of instructors. Recommended preparation: familiarity with probability theory.

EENG 450a, Applied Digital Signal Processing  J Rimas Vaisnys
An analysis, by computer, of processing requirements. Relevant probability and estimation theories applied to measurements corrupted by noise. Point estimates and system identification from random processes. MATLAB simulations verify the analysis. Prerequisite: EENG 310 or permission of instructor. QR
* EENG 451b / CPSC 456b, Wireless Technologies and the Internet of Things  Wenjun Hu
Over the last two decades or so, consumer IoT technologies have evolved from individual analogous devices, to connected devices and then interconnected networks of devices, from data collection to data management, from smart devices to intelligent interfaces. Wireless connectivity is an important driver of IoT technologies. This course aims to weave together fundamental theories of wireless communications, its application to IoT, and the design and implementation of wireless network architectures. The concepts are illustrated using examples such as WiFi and LTE/5G. Particular emphasis is placed on the interplay between concepts and their implementation in real systems. The coursework offers a practical experience, built on lab sessions involving WiFi experiments and simple IoT setups, homework involving Matlab-based analysis, and a student-defined course project that can cater to diverse interests. Students can expect to learn background knowledge of some everyday wireless technologies and how to design systems based on the fundamental communications concepts. Given the nature of these invisible signals, students also gain some experience of dealing with uncertainty in experiments and working towards open-ended goals. Depending on the programming background of the students, we may also explore backend system support in the form of edge or cloud computing. Prerequisites: 1) Introductory courses in mathematics, engineering, or computer science covering basics of the following topics: Linux skills, Matlab programming, probability, linear algebra, and Fourier transform; 2) Or by permission of the instructor. Course material will be self-contained as much as possible. The labs and homework assignments require Linux and Matlab skills and simple statistical and matrix analysis (using built-in Matlab functions). There will be a couple of introductory labs to refresh Linux and Matlab skills if needed.

* EENG 452a, Internet Engineering  Leandros Tassiulas
Introduction to basic Internet protocols and architectures. Topics include packet-switch and multi-access networks, routing, flow control, congestion control, Internet protocols (IP, TCP, BGP), the client-server model, IP addressing and the domain name system, wireless access networks, and mobile communications. Prerequisite: a college-level course in mathematics, engineering, or computer science, or with permission of instructor. QR

EENG 454b / AMTH 364b / S&DS 364b, Information Theory  Andrew Barron
Foundations of information theory in communications, statistical inference, statistical mechanics, probability, and algorithmic complexity. Quantities of information and their properties: entropy, conditional entropy, divergence, redundancy, mutual information, channel capacity. Basic theorems of data compression, data summarization, and channel coding. Applications in statistics and finance. After STAT 241. QR

* EENG 455b, Network Algorithms and Stochastic Optimization  Leandros Tassiulas
This course focuses on resource allocation models as well as associated algorithms and design and optimization methodologies that capture the intricacies of complex networking systems in communications computing as well as transportation, manufacturing, and energy systems. Max-weight scheduling, back-pressure routing, wireless opportunistic scheduling, time-varying topology network control, and energy-efficient management are sample topics to be considered, in addition to Lyapunov stability and optimization, stochastic ordering, and notions of fairness in network resource consumption. QR

* EENG 468a and EENG 469b, Advanced Special Projects  Mark Reed
Faculty-supervised individual or small-group projects with emphasis on research (laboratory or theory), engineering design, or tutorial study. Students are expected to consult the director of undergraduate studies and appropriate faculty members about ideas and suggestions for suitable topics during the term preceding enrollment. This course may only be taken once and at any appropriate time during the student’s career; it does not fulfill the senior requirement. Enrollment requires permission of both the instructor and the DUS, and submission to the latter of a one- to two-page prospectus approved by the instructor. The prospectus is due to the DUS one day prior to the date that the student’s course schedule is due.
* EENG 471a and EENG 472b, Senior Advanced Special Projects  Mark Reed
Faculty-supervised individual or small-group projects with emphasis on research (laboratory or theory), engineering design, or tutorial study. Students are expected to consult the director of undergraduate studies and appropriate faculty members about ideas and suggestions for suitable topics during the term preceding enrollment. This course is only open to seniors and is one of the courses that fulfills the senior requirement. Enrollment requires permission of both the instructor and the DUS, and submission to the latter of a one- to two-page prospectus approved by the instructor. The prospectus is due to the DUS one day prior to the date that the student's course schedule is due.

EENG 475a / BENG 475a / CPSC 475a, Computational Vision and Biological Perception  Steven Zucker
An overview of computational vision with a biological emphasis. Suitable as an introduction to biological perception for computer science and engineering students, as well as an introduction to computational vision for mathematics, psychology, and physiology students. Prerequisite: CPSC 112 and MATH 120, or with permission of instructor.  QR, SC  RP

* EENG 481b, Advanced ABET Projects  Roman Kuc
Study of the process of designing an electrical device that meets performance specifications, including project initiation and management, part specification, teamwork, design evolution according to real-world constraints, testing, ethics, and communication skills. Design project consists of electronic sensor, computer hardware, and signal analysis components developed by multidisciplinary teams. Prerequisites: EENG 310, 320, 325, and 348.  RP