ELECTRICAL & COMPUTER ENGINEERING (ECE)

ECE 1210 - The Computing Technology Inside Your Smartphone (3 Credits)

Crosslisted with ENGRI 1210

The organization of the computer system found within devices used in everyday living, such as smartphones and tablets. Computer systems are presented in a bottom up fashion, from bits to digital logic, computer organization, instruction sets, assembly language, and the connection to high-level languages. Discussion of the computing engines found in smart phones, tablets, and wearables.

Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020

Schedule of Classes (https://classes.cornell.edu/)

ECE 1410 - How Machines Learn: AI from the Perceptron to GPT (3 Credits)

Crosslisted with ENGRI 1410

This course covers learning, deep learning, and neural networks from the perceptron through modern architectures such as GPT. Students will build intuition for how machines learn, explore foundational neural architectures, implement learning algorithms on neural networks, learn about small-scale and large-scale hardware architectures for leaning and AI, efficiency of and energy cost of AI systems, and reflect on the ethical and societal implications of AI. More advanced topics such as recurrent neural networks (RNNs), long short-term memory (LSTMs), Transformers and Large Language Models will be introduced at a high level with emphasis on intuition and demonstrations rather than mathematical details. The course emphasizes concepts and applications with mathematical tools that freshmen can wield to connect engineering tools with AI methods. The course also discusses AI hardware topics related to power consumption, computational infrastructure requirements, and the role of large-scale data centers in enabling AI systems. Some programming experience in Python (or an equivalent programming language) will be useful in completing assignments and design projects.

Last Four Terms Offered: Spring 2026

Learning Outcomes:

- Analyze multi-layer perceptron neural networks.
- Implement learning algorithms (e.g. gradient descent) on neural networks.
- Analyze hardware costs in terms of energy and infrastructure for deep learning neural networks.
- Demonstrate understanding of Transformers and Large Language Models.
- Demonstrate teamwork in pursuing design challenges and goals.
- ABET 1: Demonstrate ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- ABET 2: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
- ABET 3: An ability to communicate effectively with a range of audiences.
- ABET 4 An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
- ABET 7: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Schedule of Classes (https://classes.cornell.edu/)

ECE 2100 - Introduction to Circuits for Electrical and Computer Engineers (4 Credits)
Crosslisted with ENGRD 2100
This course is an introduction to electronic circuits. We start with the basic quantities used to characterize circuit operation (like current, voltage, and power) and then enforce several physical laws to form the basis of our approach to circuit analysis. Networks comprising passive circuit elements such as resistors, inductors, and capacitors will be examined under constant dc, transient, and sinusoidal steady-state conditions. Active components including transistors and Op-Amps will be introduced and used to build simple amplifiers and switching power converters. Many of these ideas will be unified mathematically through the use of Laplace transforms and associated transfer functions. In the lab part of the course, we will learn how to use modern instruments to test circuits, and explore the concepts from lecture applied to real circuits. Finally, we will develop some simple modeling software in MATLAB to numerically predict the results from analysis and experiment.
Prerequisites: MATH 1920 or PHYS 1112.
Corequisites: MATH 2930 or PHYS 2213.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 2200 - Signals and Information (4 Credits)
Crosslisted with ENGRD 2220
Last Four Terms Offered: Spring 2021, Fall 2020, Spring 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 2300 - Digital Logic and Computer Organization (4 Credits)
Crosslisted with ENGRD 2300
This course provides an introduction to the design and implementation of digital circuits and microprocessors. Topics include transistor network design, Boolean algebra, combinational circuits, sequential circuits, finite state machine design, processor pipelines, and memory hierarchy. Design methodology using both discrete components and hardware description languages is covered in the laboratory portion of the course.
Prerequisites: CS 1110 or CS 1112.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Learning Outcomes:

- Understand Boolean logic and state machines as theoretical foundations of digital systems.
- Be able to conceive, analyze, design, and build combinational and sequential digital logic solutions to everyday problems.
- Comprehend the basic structure and functionality of ROM and RAM memories.
- Understand the basic structure and functionality of central processing units, and build a simple one using FPGAs.
- Understand the structure and operation of memory hierarchies and input/output systems.

Schedule of Classes (https://classes.cornell.edu/)

ECE 2400 - Computer Systems Programming (4 Credits)
Crosslisted with ENGRD 2140
Computer systems programming involves developing software to connect the low-level computer hardware to high-level, user-facing application software. This course will provide a strong foundation in the principles, practices, and art of computer systems programming using the C and C++ programming languages. Students will learn procedural programming in C and how to theoretically analyze and practically implement basic data structures and algorithms. Students will transition to C++ to explore object-oriented, generic, functional, and concurrent programming before exploring advanced data structures and algorithms involving trees, tables, and graphs. Students will explore systems programming using the POSIX standard library. The course includes a series of programming assignments for students to put the principles they have learned into practice. For more information, see https://www.csl.cornell.edu/courses/ece2400 (https://www.csl.cornell.edu/courses/ece2400/).
Prerequisites: CS 1110 (preferred) or CS 1112.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 2720 - Data Science for Engineers (4 Credits)
Crosslisted with ENGRD 2720
An introduction to data science for engineers. The data science workflow: acquisition and cleansing, exploration and modeling, prediction and decision making, visualization and presentation. Tools for data science including numerical optimization, the Discrete Fourier Transform, Principal Component Analysis, and probability with a focus on statistical inference and correlation methods. Techniques for different steps in the workflow including outlier detection, filtering, regression, classification, and techniques for avoiding overfitting. Methods for combining domain-agnostic data analysis tools with the types of domain-specific knowledge that are common in engineering. Ethical considerations. Optional topics include classification via neural networks, outlier detection, and Markov chains. Programming projects in Python.
Prerequisites: MATH 1920, and either CS 1110 or CS 1112.
Corequisites: MATH 2940.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 3030 - Electromagnetic Fields and Waves (4 Credits)
Covers static, quasi-static, and dynamic electromagnetic fields and waves. Topics include Maxwell's equations (integral and differential forms), fields of charge and current distributions, boundary conditions, fields near conductors, method of images, material polarization and dielectrics; energy, work, and power in electromagnetic systems; wave propagation and polarization, waves in media (dielectrics, conductors, and anisotropic materials); reflection, transmission, and refraction at media interfaces; guided waves in transmission lines, Smith charts, transients; metallic and dielectric waveguides; radiation and antennas, antenna arrays, electric circuits for transmission and reception, aperture antennas and diffraction.
Prerequisites: PHYS 2213, MATH 2930, and ECE 2100/ENGRD 2100.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Be able to use vector calculus to solve Maxwell's Equations describing the electromagnetic static and dynamic fields in a variety of geometries and coordinate systems.
- Be able to analyze electromagnetic wave propagation in free space and in different materials.
- Be able to analyze electromagnetic wave propagation through guiding structures (metal and dielectric waveguides and transmission lines) under various loading conditions, and design impedance matching circuits for optimum power transfer.
- Be able to analyze and design wire antennas, arrays and dishes.

Schedule of Classes (https://classes.cornell.edu/)

ECE 3100 - Introduction to Probability and Inference for Random Signals and Systems (4 Credits)
Probability theory is a mathematical discipline that allows one to reason about uncertainty: it helps us to predict uncertain events, to make better decisions under uncertainty, and to design and build systems that must operate in uncertain environments. This course will serve as an introduction to the subject on the modeling and analysis of random phenomena and processes, including the basics of statistical inference in the presence of uncertainty. Topics include probability models, combinatorics, countable and uncountable sample spaces, discrete random variables, probability mass functions, continuous random variables, probability density functions, cumulative distribution functions, expectation and variance, independence and correlation, conditioning and Bayess rule, concentration inequalities, the multivariate Normal distribution, limit theorems (including the law of large numbers and the central limit theorem), Monte Carlo methods, random processes, and the basics of statistical inference. Applications to communications, networking, circuit design, computer engineering, finance, and voting will be discussed throughout the semester.
Prerequisites: MATH 2940 and PHYS 2213, or equivalent.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Become fluent in combinatorics and set manipulations so as to make probabilistic predictions involving discrete models.
- Learn to recognize random phenomena in ECE applications, select appropriate mathematical models for them, and solve those models by exploiting mathematical structure such as statistical independence.
- Understand the statements of key limit theorems and be able to apply those theorems to make decisions in the presence of uncertainty.
- Formulate estimation and detection problems from described physical scenarios and compute the optimal estimators/decision rules for those scenarios.

Schedule of Classes (https://classes.cornell.edu/)

ECE 3140 - Embedded Systems (4 Credits)
Crosslisted with CS 3420
An introduction to the design of embedded systems, with an emphasis on understanding the interaction between hardware, software, and the physical world. Topics covered include assembly language programming, interrupts, I/O, concurrency management, scheduling, resource management, and real-time constraints.
Prerequisites: ECE 2300/ENGRD 2300.
Enrollment Information: Recommended prerequisite: ECE 2400/ENGRD 2140.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 3150 - Introduction to Microelectronics (4 Credits)
This is a comprehensive undergraduate level course on microelectronics. Topics covered include basic semiconductor physics, electrons and holes in semiconductors, electrical transport in semiconductors, PN junctions and diodes, photodetectors and solar cells, Metal-Oxide-Semiconductor (MOS) capacitors, MOS field effect transistors (FETs), bipolar junction transistors (BJTs), large signal and small signal models of electronic devices, single stage amplifiers, multistage amplifiers, differential amplifiers, analog circuit analysis and design, high-frequency models of devices, high-frequency circuit analysis, digital logic and MOS logic devices, complimentary MOS (or CMOS) logic gates, fundamental trade-offs in high speed analog and digital circuit design. The coursework includes labs and a final project.
Prerequisites: ECE 2100/ENGRD 2100 and PHYS 2213.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 3200 - Foundations Machine Learning (4 Credits)
This is an introductory course in machine learning (ML) that covers basic theory, algorithms, and applications. The class will develop a principled understanding of the various facets of ML and encompass fundamental (supervised and unsupervised) ML primitives that underpin modern technologies. Specifically, the learning theory content will cover the statistical learning paradigm, empirical risk minimization, generalization, bias-variance tradeoff, regularization, and validation. The supervised learning chapter will cover regression, the maximum likelihood principle, generalized linear models, support vector machines, and naïve Bayes. Unsupervised learning methods will include clustering, k-means, EM algorithm, factor analysis, and other dimensionality reduction techniques. The final few lectures will be devoted to large language models and the generative pre-trained transformer (GPT) architecture, as well as topics in ethics and fairness in machine learning. Our treatment of the material will start from theoretical principles, and build up towards implementation and applications dealing with text data, handwriting, music, images, etc. To that end, the course will incorporate a programming.
Prerequisites: MATH 1910 and MATH 2940.
Forbidden Overlaps: CS 3780, CS 5780, ECE 3200, ECE 5420, ORIE 3741, ORIE 5741, STSCI 3740, STSCI 5740
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2010
Schedule of Classes (https://classes.cornell.edu/)

ECE 3250 - Signals and Systems (4 Credits)
Course aims to provide students with a rigorous treatment of the fundamentals of discrete- and continuous-time signals and systems. The course makes use of sophisticated tools such as vector spaces of signals (e.g. bounded, summable, and square-summable signals) and orthogonal expansions in Hilbert space in addition to covering standard material on time- and frequency-domain analysis of signals and systems, including discrete- and continuous-time convolution, Fourier series, continuous- and discrete-time Fourier transforms, sampling theory, the DFT and FFT, and spectrograms. Homework assignments include a computational component where appropriate.
Prerequisites: MATH 2930, MATH 2940, or permission of instructor.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Help students achieve a sophisticated understanding of fundamental signals and systems concepts.
- Help students achieve a facility with sophisticated signal-analysis tools useful in applications to ECE and beyond.
- Help students attain an appreciation of the central role that advanced mathematics plays in modeling, analysis, and design of engineering systems.

Schedule of Classes (https://classes.cornell.edu/)

ECE 3400 - Intelligent Physical Systems (4 Credits)
This course includes topics on microcontrollers, sensors, motors & actuators, and circuit & software debugging, with an end-of-semester fully operational robot demonstration. Students will learn the value and trade-offs between theory/simulation and physical implementations, and gain familiarity with teamwork, leadership skills, time management, and how to disseminate work to a broader audience through wiki-pages.
Prerequisites: ECE 2100, ECE 2300. Recommended prerequisite: ECE 2400 or equivalent. Recommended pre- or corequisite: ECE 3250.
Last Four Terms Offered: Fall 2022, Fall 2021, Spring 2021, Fall 2019
Learning Outcomes:

- Ability to evaluate what problems are best solved in software and/or electronics, as well as the trade-offs between theory, simulation, and practical implementations.
- Ability to work effectively on a team, as a member, and as a leader.
- Ability to effectively communicate through online media, the process through which the project was implemented.
- Awareness of professional and ethical responsibilities in the context of the course.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4060 - Quantum Physics and Engineering (4 Credits)
Introduction to quantum physics and engineering for advanced undergraduate and beginning graduate students. Topics covered include historical developments, quantum postulates, Schrodinger equation, quantum states and observables, measurement in quantum mechanics, quantum confined states in potential wells and atoms, quantum tunneling, uncertainty relations, Dirac notation, angular momentum and spin, quantum dynamics, time-independent and time-dependent perturbation theories, quantum two-level systems, quantum information and the qubit, quantum computation and quantum circuits, identical particles, quantum statistics for fermions and bosons, fundamentals of quantum statistical physics, quantization of light and the photon, quantization of simple mechanical and electrical superconducting circuits. The course will enable students to take advanced courses in areas related to electronic and optical devices, solid state physics and material science, and quantum information and computation.
Prerequisites: PHYS 2214 and MATH 2930.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 4070 - Physics of Semiconductors and Nanostructures (4 Credits)
Covers basic solid state and semiconductor physics relevant for understanding electronic and optical devices. Topics include crystalline structures, bonding in atoms and solids, energy bands in solids, electron statistics and dynamics in energy bands, effective mass equation, carrier transport in solids, Boltzmann transport equation, semiconductor homo- and hetero-junctions, optical processes in semiconductors, electronic and optical properties of semiconductor nanostructures, semiconductor quantum wells, wires, and dots, electron transport in reduced dimensions, semiconductor lasers and optoelectronics, high-frequency response of electrons in solids and plasmons.
Prerequisites: ECE 4060.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Learn basic principles of solid state and semiconductor physics needed to understand modern electronic and photonic devices.
- Learn how engineering materials and structures at the nanoscale enables novel electronic and photonic properties for a wide variety of engineering applications.
- Learn the relationship between basic science and engineering applications.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4110 - Random Signals in Communications and Signal Processing (4 Credits)
Introduction to models for random signals in discrete and continuous time; Markov chains, Poisson process, queuing processes, power spectral densities, Gaussian random process. Response of linear systems to random signals. Elements of estimation and inference as they arise in communications and digital signal processing systems.
Prerequisites: ECE 2720 or ECE 3100, and ECE 3250.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Knowledge of a variety of mathematical models for random phenomena.
- Ability to classify models with respect to stationarity, Markov property, asymptotics, and more.
- Ability to make optimal inferences and estimates with respect to such criteria as minimum error probability, and minimum mean square error.
- Become aware of applications to communications, machine learning, statistical physics and more.
- Response of linear systems to random process inputs (time permitting).

Schedule of Classes (https://classes.cornell.edu/)

ECE 4130 - Introduction to Nuclear Science and Engineering (3 Credits)
Crosslisted with CHEME 4130, MAE 4580, AEP 4130
Introduces the fundamental concepts of nuclear science and engineering, including nuclear structure, radioactivity, nuclear reactions and the interaction of neutrons, charged particles, x-rays and gamma-rays with matter. Discusses the neutron chain reaction and its control in the core of a fission reactor. Different reactor designs are introduced and discussed along with their safety features. Other topics include radiation shielding and aspects of the nuclear fuel cycle, including isotope separation, fuel reprocessing, waste disposal and sustainability
Prerequisites: PHYS 2214.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2020, Fall 2019
Learning Outcomes:

- Demonstrate basic conceptual understanding of atomic and nuclear physics, quantum mechanics and electrostatics relevant to the interaction of radiation with matter, and especially neutron interactions.
- Demonstrate a basic understanding o the fission process and neutron chain reactions.
- Know and understand the advantages and disadvantages of various combinations of fuel and other materials (moderator, coolant, structure) for safety and sustainability.
- Understand the design and operation of a nuclear reactor core as a critical or near critical mass of fissile and other materials in steady state and in times of slowly changing power.
- Demonstrate the ability to calculate the amount of fuel needed by a power reactor per year as well as the amount of nuclear waste that will be produced and its decay rate.
- Know and understand the interaction of radiation with biological systems and the consequences thereof, and methods of shielding to reduce radiation effects.
- Understand case histories of nuclear reactor accidents.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4150 - GPS: Theory and Design (4 Credits)
Crosslisted with MAE 4150, EAS 4150
Analysis of GPS operating principles and engineering practice with a culminating design exercise. GPS satellite orbital dynamics, navigation data modeling, position/navigation/timing solution algorithm, receiver and antenna characteristics, analysis of error and accuracy, differential GPS.
Prerequisites: 3000-level engineering course with advanced math content (e.g., ECE 3030 or MAE 3260).
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2020, Spring 2018
Learning Outcomes:

- Students will be able to develop an understanding of orbital mechanics with non-Keplerian perturbations and reference frames adequate to calculate GPS satellite positions in absolute and local coordinates.
- Students will be able to use to use the GPS observables, their physical models, and the multi-variable version of Newton's nonlinear equation-solving method to calculate a navigation solution and a velocity solution.
- Students will be able to gain an understanding of the sources of ranging errors and how they map to navigation errors.
- Students will be able to collect raw GPS data in a laboratory environment, to analyze its properties, including its noise properties, and to use it to derive useful position, navigation, timing, and velocity information.
- Students will be able to implement an advanced analysis or design solution to a GPS problem, test it experimentally, and effectively communicate the results in a final report.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4160 - Fast Robots (4 Credits)
Crosslisted with MAE 4190
The course focus is on systems level design and implementation of fast and dynamic autonomous robots. With the recent DIY movement, design of kinematic robots is largely becoming a software challenge. In dynamic robots, however, any latency or noise can be detrimental. We will design a fast autonomous car, explore dynamic behaviors, acting forces, sensors, and reactive control on an embedded processor, as well as the benefit of partial off-board computation. Students will learn how to derive design specifications from abstract problem descriptions and gain familiarity with rapid prototyping techniques, system debugging, system evaluation, and online dissemination of work.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students will learn how to robustly integrate systems consisting of electronics, software, and mechanics operating in the real world.
- Students will learn how to translate probabilistic control and planning methods to practical robots with hardware and processing constraints.
- Students will learn how to disseminate their work to their peers and an engineering audience.
- Students will learn how to predict the likely social and environmental effects of their design.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4180 - Autonomous Mobile Robots (3 Credits)
Crosslisted with MAE 4180, CS 4758
Creating robots capable of performing complex tasks autonomously requires one to address a variety of different challenges such as sensing, perception, control, planning, mechanical design, and interaction with humans. In recent years many advances have been made toward creating such systems, both in the research community (different robot challenges and competitions) and in industry (industrial, military, and domestic robots). This course gives an overview of the challenges and techniques used for creating autonomous mobile robots. Topics include sensing, localization, mapping, path planning, motion planning, obstacle and collision avoidance, and multi-robot control.
Prerequisites: MATLAB programming experience.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand and implement localization and mapping algorithms using different sensor modalities.
- Students will be able to generate a path and the motion for a robot moving around an area with obstacles.
- Students will be able to understand and implement the concepts of different approaches for motion planning such as roadmaps, feedback control, and sampling based methods.
- Students will be able to apply the tools learned in the class to physical robots.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4200 - Fundamentals of Machine Learning (4 Credits)
The course will be devoted to understanding, implementation, and applications of various machine learning primitives. This course is intended to have three modules, and within each we will cover basic theory, and implementations. The modules will be supervised learning, unsupervised learning, and finally topics that are motivated by engineering applications such as speech recognition, and recommendation systems. Supervised learning will include regression, support vector machines, decision trees, random forests, naive Bayes, boosting and bagging. Unsupervised learning includes clustering, k-means, k-NN, principal components analysis and other dimensionality reduction methods. We will give particular emphasis on engineering applications, e.g., text data, hand-writing, music, image, and time series data, and categorical datasets such those in recommendation systems. The course will have a programming component, which will be administered in the form of assignments, and in-class-kaggle competitions.
Prerequisites: MATH 2940, ECE 3100 or STSCI 3080 or ECE 3250 or equivalents.
Enrollment Information: Enrollment limited to: juniors and seniors.
Last Four Terms Offered: Spring 2024, Spring 2023, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 4210 - Network Systems and Games (3 Credits)
Network systems pervade our society in both social and technological contexts. On the one hand, social networks play a central role in the transmission of information and viruses with fundamental consequences for product marketing, technology adoption, voting decisions, spread of false news and epidemiology. On the other hand, network topology fundamentally affects the performance and resilience properties of large-scale multi-agent systems, such as the electric power grid, the internet of things, traffic or robotic sensor networks.
Prerequisites: MATH 2930 and MATH 2940.
Last Four Terms Offered: Spring 2025, Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 4230 - Computer Vision (3 Credits)
A first course in computer vision for advanced undergraduate students; that is, the analysis by computer of multidimensional signals provided by imaging sensors including image sequences and three-dimensional images for primarily autonomous applications. Basic techniques for image processing and feature extraction are covered in lectures; topics include image formation, image filtering, edge detection, region growing, shape description, and machine learning for computer vision. Machine learning methods including convolution neural networks, deep learning models for focus attention and image segmentation. The course focus is on the machine interpretation of images for autonomous decision making.
Prerequisites: MATH 2940 and ECE 2720.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Demonstrate an understanding of precision image review and annotation.
- Demonstrate an understanding of image filtering and image segmentation.
- Demonstrate an understanding of deep learning methods for object identification and region segmentation.
- Demonstrate a knowledge the image analysis methods. for image sequences and 3D images.
- Demonstrate a knowledge in computer vision algorithm design and development including a quantitative evaluation of algorithm performance.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4240 - Robot Perception (3 Credits)
Crosslisted with MAE 4810
An introductory course to robot perception techniques for modeling and planning heterogeneous and dynamic sensor measurements, and for processing the sensor feedback in the context of robot motions and environments. Methods for intelligent sensor fusion and robot perception in motion will be covered in detail in this course. Topics in artificial vision, acoustic propagation, and filtering will be discussed along with related algorithms inspired by neural networks, Bayesian networks, and information theory. Sensing problems and performance will be investigated in regard to benchmark problems, such as coverage, target search, target tracking, and treasure hunting, will be covered in-depth and demonstrated through applications drawn from environmental monitoring, sensing-and-pursuit games, surveillance, and human-robot interactions.
Prerequisites: ENGRD 2112 and MATH 2940 and (MATH 4710 or ENGRD 2700 or ENGRD 2720).
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021
Learning Outcomes:

- Students will be able to use methods for sensor fusion to inform robot perception.
- Students will be able to implement artificial vision, acoustic propagation, and filtering along with neural networks, Bayesian algorithms, and information theory to identify robot states.
- Students will be able to analyze benchmark problems such as coverage, target search, target tracking, and treasure hunting.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4250 - Digital Signal Processing and Statistical Inference (4 Credits)
This course introduces discrete-time signal and system models in deterministic and stochastic settings and develops signal processing and statistical inference methodologies for real-time sensing and control applications. The course is intended for upper-level undergraduate and beginning graduate engineering students in engineering departments.The course covers both deterministic and stochastic techniques. Specific topics include time and frequency domain representation of signals and systems, state-space representation, feedback, stability, linear and nonlinear filtering, signal and state estimation and tracking, hypothesis testing, and signal detection. Applications in communications and control system design are integrated into the course material.
Prerequisites: MATH 1920 and MATH 2940 and (ECE 3100 or ENGRD 2700 or ECE 2720 or MATH 4710) and ECE 3250.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Spring 2021
Learning Outcomes:

- Be able to obtain impulse response from frequency and state-space models and vice versa. Be able to analyze system stability, reachability, and observability given a linear time-invariant state space model.
- Be able to design and implement state and observer-based feedback systems that stabilize an unstable system.
- Be able to understand stationary and wide-sense stationary models of discrete-time signal and the notion of power spectrum density of a wide-sense stationary process.
- Be able to solve signal estimation and detection problems under parametric and state-space models, including implementing Wiener and Kalman filtering techniques for estimation, and using matched filtering in signal detection.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4271 - Evolutionary Processes, Evolutionary Algorithms, Evolutionary Games (3 Credits)
Course addresses a collection of topics relevant to the modeling, analysis, simulation, and optimization of large complex multi-agent systems. Course provides a standalone introduction to discrete-time Markov chains; covers the Metropolis algorithm and its generalizations; gives an introduction to the theory of genetic algorithms; and provides an introduction to evolutionary game theory, including the ESS concept, replicator dynamics, and dynamic probabilistic approaches.
Prerequisites: ECE 3100 or a strong familiarity with discrete probability.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2020
Learning Outcomes:

- Develop an understanding of discrete-time Markov chains with countable state spaces.
- Learn about the historical development of various random-search techniques.
- Attain a fairly deep understanding of the theory of genetic algorithms.
- Attain a basic understanding of evolutionary game theory and its importance in modeling and analysis of modern large-scale systems.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4300 - Lasers and Optoelectronics (4 Credits)
Introduction to the operation, physics, and application of lasers. The course covers diffraction-limited optics, Gaussian beams, optical resonators, the interaction of radiation with matter, stimulated emission, rate equations, and laser design. Examples of coherent radiation to nonlinear optics, communication, and leading-edge research are frequently used. Course concludes with a lab where students design and then build a laser.
Prerequisites: Recommended prerequisite: ECE 3030 or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2021, Fall 2018
Learning Outcomes:

- Be able to analytically design and physically construct a functional laser with simple optics.
- Understand the general operating principles of laser systems, and be knowledgeable of specific systems (e.g. tunable, ultrafast, high power, fiber and semiconductor lasers).
- Understand how to design and the physics behind continuous wave operation, mode locking, Q-switching, and harmonic generation.
- Be able to design a laser optic system using mirrors, lenses and gain media based on Gaussian beam analysis.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4320 - Integrated Micro Sensors and Actuators: Bridging the Physical and Digital Worlds (4 Credits)
Crosslisted with MAE 4320
Introduction to micro and nano devices that allow the digital world to both sense and actuate in the physical world. Design and analysis of modern MEMS/NEMS (Micro/Nano Electromechanical Systems) touch, accelerometers, gyroscopes, pressure, microphones, neural probe sensors. Design and analysis of electrostatic, piezoelectric, thermal, and magnetic actuators for frequency control and micro robotic applications. This is an interdisciplinary course drawing from mechanics, materials, solid state devices, CMOS electronics, and micro and nano fabrication. The students design, fabricate, and test a microsensor chip to implement class concepts.
Prerequisites: ECE 2100.
Last Four Terms Offered: Spring 2026, Fall 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Be able to design and model a digital app-based electronic interface to integrated sensors.
- Be able to model spring-mass equivalent models of micro/nano fabricated structures, using analysis and finite-element analysis software.
- Be able to use individual fabrication steps into a device fabrication process flow.
- Be able to design and model electromechanical models of planar surface micromachined accelerometers and gyroscopes.
- Be able to design membrane based sensors and actuators such as pressure monitors and microphones.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4330 - Microwave Circuit Design (4 Credits)
This course covers techniques to design and analyze microwave circuits. These techniques, in general, can be used for electrical devices with dimensions in the order of the operating wavelength. These devices are commonly used in RF/mm- wave wireless communication systems, quantum computing/sensing systems, and electromagnetic imaging/radar systems. Topics include planar transmission lines, network analysis, S-parameters, matching networks, resonators, power dividers/combiners, filters, and non-reciprocal devices. The course emphasizes physical understanding, intuitive design methods, and hands-on experience in using E+M simulation tools and microwave measurements.
Prerequisites: ECE 3030 and ECE 3150.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2017
Learning Outcomes:

- Analyze important building blocks in microwave/millimeter wave systems.
- Design and optimize microwave components and understand the challenges in high operating frequency.
- Develop the ability to use E+M circuit simulators and perform microwave measurements.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4360 - Nanofabrication and Characterization of Electronics (3 Credits)
This course will give an introduction to modern nanofabrication technologies with emphasis on integrated circuits manufacturing. Thermal budget, scaling of geometry, pitch and registry and control of parametric yield will be used for integration guidelines. Physical principles and process modeling will be covered in lectures and labs will include a series of fabrication steps of lithography, metallization, plasma etching and annealing to produce semiconductor devices (Schottky diodes, pn junction diodes, MOS capacitors, and MOSFETs). Recent advances in nanofabrication will be briefly reviewed for their possible technology insertion and main integration challenges.
Prerequisites: MSE 2620 or ECE 3150.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 4361 - Nanofabrication and Characterization of Electronics Laboratory (1 Credit)
This course provides an introduction to nanofabrication technologies with emphasis on Si-based integrated circuits manufacturing as well as modern electronics based on GaN, 2D materials etc. The lab, primarily taught in the Cornell Teaching Cleanroom, includes basic fabrication steps of lithography, metallization, plasma etching and annealing. A series of devices will be fabricated: solar cells, MOS capacitors and transistors, 2D transistors, GaN HEMTs and LEDs.
Prerequisites: ECE 4360, MSE 5410, or AEP 6620.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 4370 - Photonics: Fundamentals and Devices (3 Credits)
Introduction to optical waveguides and photonic devices. Review of optical wave propagation in uniform media and at interfaces. Gaussian beams and diffraction. Modes, dispersion, and fundamental relations/symmetries. Interferometers and resonators. Guided waves in optical fibers and planar dielectric systems. Perturbation theory, coupling of modes, adiabatic variation, and parallels to quantum phenomena. Electro- and acousto-optics. Survey of system applications, including photonic interconnects and quantum technologies. Numerical methods, and project design of planar optical components.
Prerequisites: ECE 3030 or AEP 3560.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students will be able to understand optical wave propagation in structured media.
- Students will be able to understand modes, modal coupling, and application in photonic devices.
- Students will be able to understand active electro- and acousto-optic devices and their applications.
- Students will be able to analyze, simulate, and design planar photonic components.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4380 - Electromagnetic and Optical Metamaterials (3 Credits)
Crosslisted with AEP 4450
Introductory Senior-level course on electromagnetic and optical metamaterials. The properties of matter can be molded and tailored on subwavelength spatial scales yielding 'metamaterials' with properties very different from naturally occurring materials, thereby opening up new directions for applications. The course introduces the electromagnetic and optical properties of surface plasmons and polaritons, artificial magnetic materials, negative-index materials, nanostructured optical materials, etc. The course also discusses the applications of these materials in diverse areas including electromagnetic cloaking and invisibility, stealth technologies, optical super-lensing, bio-chemical sensing, conformal optics, meta-surfaces, and non-reciprocal devices.
Prerequisites: ECE 3030 or AEP 3560.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 4450 - Computer Networks and Telecommunications (3 Credits)
This is a senior-level course in information networking with an emphasis on wireless technology. Examples of topics include: 5G cellular, the latest WiFi standards, Bluetooth, routing and switching, congestion control, network security, and user privacy. Though the focus will be on communication networking technologies, downstream legal and social issues that arise from design decisions will be discussed.
Prerequisites: ECE 3100.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Knowledge and understanding of how modern cellular technology, the Internet and other prominent technologies reached their current form.
- Ability to understand and analyze basic important algorithms in the Internet, such as congestion control and shortest path routing.
- Be able to understand the challenges that come with designing wireless networks and the tradeoff of corresponding solutions.
- Understand the limitation of current wired and wireless architectures. Be able to perform related analysis and design, and to predict future emphases as these technologies evolve.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4510 - Electric Power Systems I (3 Credits)
Acquaints students with modern electric power system modeling, analysis and computation. Stresses analysis techniques appropriate for power system modeling, analysis and power flow computation. Topics include transmission line models, transformers and per unit system, generator models, network matrices, power flow analysis and computation, real and reactive power control, voltage control, economic dispatch.
Prerequisites: ECE 3250.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Knowledge of a variety of mathematical models for power system components.
- Ability to classify such models as to issues of static model and dynamic model.
- Ability to make optimal inferences with respect to such criteria as minimum production cost and minimum emission (power flow and economic dispatch). Elements of optimal design are introduced.
- Response of power flow, bus voltage to power demand variations as well as power injection variations.
- Response of power system static behaviors to power system contingencies (such as line outages, transformer outages, generator tripping and huge load variations).

Schedule of Classes (https://classes.cornell.edu/)

ECE 4520 - Power Systems and Market Operations (3 Credits)
Examines the operations of electric power systems, the smart grid, and electricity markets. Topics include modeling of power systems, power flow analysis, economic dispatch, optimal power flow, unit commitments, electricity markets, demand response, smart grid technology, and transactive energy.
Prerequisites: ECE 2100, ECE 3100, and ECE 4510.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 4530 - Analog Integrated Circuit Design (4 Credits)
Overview of devices available to analog integrated-circuit designers in modern CMOS and BiCMOS processes: resistors, capacitors, MOS transistors, and bipolar transistors. Basic building blocks for linear analog integrated circuits: single-stage amplifiers, current mirrors, and differential pairs. Transistor-level design of linear analog integrated circuits, such as operational amplifiers and operational transconductance amplifiers. Layout techniques for analog integrated circuits. Throughout the course, emphasis is placed on design-oriented analysis techniques.
Prerequisites: ECE 3150.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Develop an understanding of device and circuit theory sufficient to estimate the low and high frequency behavior of linear circuits, including noise.
- Develop an intuition for analog circuit behavior in both linear and nonlinear operation.
- Be able to calculate transfer functions and Bode plots and use them to estimate the stability of an electronic system.
- Develop an ability to parse large circuits and systems into smaller, analyzable subunits, analyze them, and then apply the understanding gained from that process to analyze the system as a whole, including for noise and variation.
- Implement a circuit or subsystem at the transistor level to solve an open-ended problem and effectively communicate the constraints and critical aspects of that system.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4560 - Power Electronics (4 Credits)
Power electronics is an enabling technology for sustainable and energy efficient systems, as all renewable energy sources (including solar and wind) and efficient electrical loads (including LED lighting and electric vehicles) require a power electronic converter to interface them with the electrical grid. Power electronic converters, being inherently non-linear/time-variant circuits, cannot be analyzed using linear time-invariant (LTI) circuit analysis techniques, nor conventional small-signal linearization techniques taught in introductory circuits (ECE 2100) and microelectronics (ECE 3150) courses. This course, which will follow ECE 3150, will introduce advanced circuit analysis and modeling techniques required to predict the steady-state and dynamic behavior of power electronic converters. The course will also introduce seniors and first-year graduate students to other advanced topics which are required for the analysis and design of power converters, including power semiconductor device modeling, thermal modeling, magnetic component modeling, electromagnetic interference (EMI) filter design, and switching converter control design, at a level appropriate for them. This course will equip ECE students with the theoretical and practical skills needed to innovate in the area of power electronics, and allow them to succeed in graduate school and in the rapidly growing job market for power electronic engineers.
Prerequisites: ECE 3150.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 4570 - Semiconductor Electronic and Photonic Devices (4 Credits)
The class develops the fundamentals of semiconductor electronic and photonic devices that power today's computation, communication, and memory industries. It relates the basics of pn junctions to their applications in solar cells, light emitting diodes, and lasers. Majority and minority carrier transport in heterostructure bipolar transistors is related to gain and speed limits of amplifiers for 5G communications and beyond. Schottky diodes and their applications in power electronics, and in field effect transistors of many flavors ranging from Silicon CMOS and FinFETs to GaN high electron mobility transistors are covered. Tunneling transport, flash memory, and DRAM devices are discussed. The course uses industrially relevant simulation tools, and the laboratory component gives students firsthand experience of measuring and appreciating the power and the limitations of semiconductor devices, and the reason for their revolutionary influence on our lives and society.
Prerequisites: ECE 3150.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Obtain a well-grounded understanding of semiconductor device operation and advanced ideas in use in microelectronic industry.
- Learn through simulations, the aspects of physical behavior that analytic solutions are incomplete at and their more complete description of operational physics.
- Apply device fundamentals and simulation techniques to design modern nanoscale device structures.
- Develop comprehensive skills straddling electronics, integration, and devices as used in integrated circuits leading to effective communication of results.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4590 - Thin-Film Materials Science (3 Credits)
Provides a fundamental understanding of processing/structure/property relation in thin films, with an emphasis on behaviors that differ from those observed in classical bulk materials. Topics include vacuum technology, deposition techniques, surface energies, surface kinetics, nucleation and growth, homoepitaxy, heteroepitaxy, microstructure, stress in thin films, and electromigration. The course will impart a basic perspective on thin film synthesis and properties and will develop your ability to analyze materials issues and formulate solutions.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 4670 - Digital Communication System Design (4 Credits)
The goal of this course is to understand how state-of-the-art digital communication systems are designed and why they are designed in the way they are. The course will cover communication theory, transceiver algorithms that enable reliable communication, wireless channels, and modern communication standards (such as 3GPP LTE and WiFi). The students will design a working audio-band communication system that relies on orthogonal frequency-division multiplexing (OFDM).
Prerequisites: ECE 2720 and ECE 3250.
Forbidden Overlaps: ECE 4670, ECE 5670
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 4740 - Introduction to Digital (VLSI) Design (4 Credits)
An introduction to digital very large-scale integration (VLSI) design from architectural considerations down to the layout level. Lecture, labs, and homework topics emphasize disciplined synchronous VLSI design and include topics of CMOS logic, layout, and timing; computer-aided design and analysis tools; electrical and performance considerations.
Prerequisites: ECE 3150.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Quantitatively evaluate CMOS technology parameters for digital applications.
- Design digital circuit modules at the module timing, circuit schematic and layout levels.
- Perform digital circuit simulation and verification in the CAD software.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4750 - Computer Architecture (4 Credits)
Crosslisted with CS 4420
This course aims to provide a strong foundation for students to understand modern computer system architecture and to apply these insights and principles to future computer designs. The course is structured around the three primary building blocks of general-purpose computing systems: processors, memories, and networks. The first half of the course focuses on the fundamentals of each building block. Topics include processor microcoding and pipelining; cache microarchitecture and optimization; and network topology, routing, and flow control. The second half of the course delves into more advanced techniques and will enable students to understand how these three building blocks can be integrated to build a modern shared-memory multicore system. Topics include superscalar execution, branch prediction, out-of-order execution, register renaming and memory disambiguation; VLIW, vector, and multithreaded processors; memory protection, translation, and virtualization; and memory synchronization, consistency, and coherence. This course includes a significant project decomposed into five lab assignments. Throughout the semester, students will gradually design, implement, test, and evaluate a complete multicore system capable of running real parallel applications at the register-transfer level.
Prerequisites: ECE 3140/CS 3420, or CS 3410.
Enrollment Information: Recommended prerequisite: students should feel comfortable working with a hardware description language such as Verilog, SystemVerilog, or VHDL.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Describe computer architecture concepts and mechanisms related to the design of modern processors, memories, and networks and explain how these concepts and mechanisms interact.
- Apply this understanding to new computer architecture design problems within the context of balancing application requirements against technology constraints; more specifically, quantitatively assess a design's execution time in cycles and qualitatively assess a design's cycle time, area, and energy.
- Evaluate various design alternatives and make a compelling quantitative and/or qualitative argument for why one design is superior to the other approaches.
- Demonstrate the ability to implement and verify designs of varying complexity at the register-transfer-levels.
- Create new designs at the register-transfer-level and the associated effective testing strategies.
- Write concise yet comprehensive technical reports that describe designs implemented at the register-transfer-levels, explain the testing strategy used to verify functionality, and evaluate the designs to determine the superior approach.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4760 - Digital Systems Design Using Microcontrollers (4 Credits)
Design of real-time digital systems using microprocessor-based embedded controllers. Students working in pairs design, debug, and construct several small systems that illustrate and employ the techniques of digital system design acquired in previous courses. The content focuses on the laboratory work. The lectures are used primarily for the introduction of examples, description of specific modules to be designed, and instruction in the hardware and high-level design tools to be employed.
Prerequisites: ECE 3140, or MAE 3780, or CS 3420.
Last Four Terms Offered: Fall 2025, Spring 2025, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 4770 - Foundations of Robotics (4 Credits)
Crosslisted with CS 4750, MAE 4760
Robotics is interdisciplinary and draws inspiration from many different fields towards solving a variety of tasks in real-world environments using physical systems. This course is a challenging introduction to basic computational concepts used broadly in robotics. By the end of this course, students should have a fundamental understanding of how the different sub-fields of robotics such as kinematics, state-estimation, motion planning, and controls come together to develop intelligent behaviors in physical robotic systems. The mathematical basis of each area will be emphasized, and concepts will be motivated using common robotics applications. Students will be evaluated using a mixture of theoretical and programming exercises throughout the semester.
Prerequisites: CS 1112, CS 2110, CS 2800, MATH 1920, MATH 2940 or their equivalents.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 4800 - Optimal System Analysis and Design (3 Credits)
Introduction to optimization theory and algorithms for system analysis and design. Topics include linear programming, convex programming, duality. We may touch dynamic programming around the end if time permits. Application will be discussed in various areas including geometric problems, networks, control, circuits, signal processing, and communications.
Prerequisites: MATH 1920 and MATH 2940.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 4840 - Introduction to Controlled Fusion: Principles and Technology (3 Credits)
Crosslisted with AEP 4840, MAE 4590
Introduction to the physical principles and various engineering aspects underlying power generation by controlled fusion. Topics include: fuels and conditions required for fusion power and basic fusion-reactor concepts, fundamental aspects of plasma physics relevant to fusion plasmas and basic engineering problems for a fusion reactor, and an engineering analysis of proposed magnetic and/or inertial confinement fusion-reactor designs.
Enrollment Information: Recommended prerequisite: one of the following: PHYS 1112, PHYS 2213, PHYS 2214, or equivalent background in electricity and magnetism and mechanics.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Understand the scientific basis for controlled fusion by both magnetic confinement and inertial confinement approaches, as well as the technological requirements for practical electric power generation by the controlled fusion process.
- Be able determine the energy release of any nuclear reaction or reaction chain using the mass-energy relationship, and be able to solve well-posed engineering problems in plasma physics as applied to controlled fusion using Maxwell's equations and the equations of motion of charged particles in electric and magnetic fields.
- Be able to solve well-posed engineering problems in energy generation by controlled fusion having to do with the properties of materials in the presence of neutron irradiation and other relevant processes.
- Understand the fundamental role played by energy in our society and in the developing world, the potential role fusion can play, and the reasons that it is potentially more attractive than fission-based electric power generation.
- Be able to determine the state-of-the-art of different aspects of fusion reactor design by independent study using books, journals, conference proceedings, reports on the web and personal communication with experts.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4870 - Introduction to Radar Remote Sensing (3 Credits)
Crosslisted with EAS 4870
Fundamentals of radar, antennas, and remote sensing. Exposes students to the principles underlying the analysis and design of antennas used for communication and for radar-related applications. Students also encounter both a mathematical and a practical description of how radars function, how their performance can be optimized for different applications, and how signals acquired by them can be processed. The objective is to familiarize students with a wide variety of radars rather than turn them into practicing radar engineers. Each topic is developed from basic principles so students with a wide variety of backgrounds are able to take the course. Emphasizes radar applications in geophysics, meteorology and atmospheric sciences, and astronomy and space sciences. Gives special attention to radar remote sensing of the Earth from spacecraft.
Prerequisites: PHYS 2208 or PHYS 2213 or equivalent, or permission of instructor.
Distribution Requirements: (OPHLS-AG), (PHS-AS)
Last Four Terms Offered: Spring 2026, Spring 2024, Spring 2022, Spring 2019
Learning Outcomes:

- Appreciate the historical, scientific, and sociological impact of radar systems.
- Understand the reciprocity theorem and its profound consequences.
- Learn to evaluate antenna performance using analysis and numerical methods, including computer algebra.
- Be able to design antennas, radar systems, and remote sensing experiments for specific tasks.
- Learn to design waveforms and process signals produced by radars and other instruments.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4880 - Radio Frequency Systems (3-4 Credits)
This course addresses the design of radio-frequency links in the component view to enable eventual full-duplex, multi-access wireless network. The analysis will reside mostly in the signal (SIMULINK) level instead of the circuit implementation, although the nonideal circuit characteristics will be reflected in the signal representation. Federal Communications Commission (FCC) and Occupational Safety & Health Administration (OSHA) standards will be introduced. Existing standard protocols will be selectively introduced including FM, TV broadcast, Bluetooth, Z-wave, Zigbee and Wi-fi to enable intuitive understanding of RF system tradeoffs.
Prerequisites: ECE 3030.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 4910 - Principles of Neurophysiology (4 Credits)
Crosslisted with BIONB 4910, BME 4910
Laboratory-oriented course designed to teach the concepts and tools of cellular neurophysiology through hands-on experience with extracellular and intracellular electrophysiological techniques, and computer acquisition and analysis of laboratory results. Students explore signal transmission in the nervous system by examining the cellular basis of resting and action potentials, and synaptic transmission and optogenetic control of behavior and physiology. Lecture time is used to review nervous system physiology, introduce laboratory exercises, discuss lab results and primary research papers, and for presentation of additional experimental preparations and methods. Invertebrate preparations are used as model systems.
Prerequisites: one of the following courses: general biology, BIONB 2220, physiology covering neuronal excitability and synaptic transmission, or permission of instructor.
Distribution Requirements: (BIO-AS), (BSC-AG, OPHLS-AG)
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students should understand the contemporary experimental paradigms in modern neurophysiology and become technically competent with the extracellular and intracellular recording techniques used to explore nervous system physiology.
- Students should deepen their understanding of the ionic mechanisms underlying neuronal excitability and synaptic communication in the nervous system.
- Students should develop their skills in communicating scientific results effectively through written lab reports and oral presentations.
- Students should refine their critical reading skills of primary scientific literature.
- Students should refine their ability to develop testable hypotheses, and develop independent scientific thinking.

Schedule of Classes (https://classes.cornell.edu/)

ECE 4920 - ECE Technical Writing (1 Credit)
Technical writing aimed at having students write up their ECE projects in a formal fashion, with a view to publication. Projects may be existing, or may be created as part of the independent study, but the writing requirement will match the current College technical writing requirement.
Prerequisites: ECE 4760 or ECE 5760.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 4950 - Special Topics in Electrical and Computer Engineering (3 Credits)
Seminar, special interest, or temporary course.
Last Four Terms Offered: Spring 2026, Fall 2023, Spring 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 4960 - Special Topics in Electrical and Computer Engineering (3 Credits)
Seminar, special interest, or temporary course.TermTopicInstructorSpringNetwork Dynamics and GamesF. Parise
Last Four Terms Offered: Spring 2023, Fall 2022, Spring 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 4980 - Supervised Teaching Experience (1-2 Credits)
This course is designed to give qualified undergraduates experience through actual involvement in planning and teaching courses under the supervision of department faculty. Students cannot receive both pay and credit for the same hours of preparation and teaching. Enrollment is with permission of instructor only. One credit of ECE 4980 is equivalent to 5 weekly work hours, including both student contact hours and preparatory/other time.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 4990 - International Research Internship (6-12 Credits)
Seminar, special interest, or temporary course.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Summer 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 4998 - Electrical and Computer Engineering Group Projects (1-4 Credits)
Group study, analysis, and, usually, experimental tests in connection with a special engineering project chosen by the students after consultation with the faculty member directing the project. New projects are added upon faculty request. Written progress reports are required.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 4999 - Electrical and Computer Engineering Independent Projects (1-4 Credits)
Individual study or directed reading in connection with a special engineering problem chosen by the student after consultation with the faculty member directing the project. An engineering report on the project is required. Students must make individual arrangements with a faculty sponsor.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 5010 - Professional Seminar for M.Eng. Students (1 Credit)
This seminar introduces students to professional issues that are important as they begin their professional career. Topics include M.Eng. ECE project options; professional expectations; project planning and management; effective teamwork; technical writing and communications; impact of environmental, economic, and societal constraints in design; entrepreneurship possibilities; and career planning issues.
Enrollment Information: Enrollment limited to: ECE M.Eng. students.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 5090 - Principles of Neurophysiology (4 Credits)
Crosslisted with BIONB 5910, BME 5320
Laboratory-oriented course designed to teach the concepts and tools of cellular neurophysiology through hands-on experience with extracellular and intracellular electrophysiological techniques, and computer acquisition and analysis of laboratory results. Students explore signal transmission in the nervous system by examining the cellular basis of resting and action potentials, and synaptic transmission. Lecture time is used to review nervous system physiology, introduce laboratory exercises, discuss lab results and primary research papers, and for presentation of additional experimental preparations and methods. Invertebrate preparations are used as model systems. Students must complete and additional semester-long project. The project includes exploration of experimental neuroscience questions not covered in the undergraduate laboratory class, novel, low cost instrumentation design, computational approaches to nervous system function and development of active learning activities. It will require a project proposal early in the semester, and a final project presentation and research journal style paper at the end of the semester.
Prerequisites: one of the following courses: general biology, BIONB 2220, physiology covering neuronal excitability and synaptic transmission, or permission of instructor.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students should understand the contemporary experimental paradigms in modern neurophysiology and become technically competent with the extracellular and intracellular recording techniques used to explore nervous system physiology.
- Students should deepen their understanding of the ionic mechanisms underlying neuronal excitability and synaptic communication in the nervous system.
- Students should develop their skills in communicating scientific results effectively through written lab reports and oral presentations.
- Students should refine their critical reading skills of primary scientific literature.
- Students should refine their ability to develop testable hypotheses, and develop independent scientific thinking.
- Graduate students will be able to prioritize, rate, evaluate, compare and contrast, and summarize Neuroscience research literature.
- Graduate students will be able to lead discussion of scientific literature, and justify, construct a scientific argument, and investigate reliability of research findings.
- Graduate students will be able to analyze and interpret research methods and data, design experiments to test hypotheses, and teach active learning activities.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5110 - Random Signals in Communications and Signal Processing (3-4 Credits)
Introduction to models for random signals in discrete and continuous time; Markov chains, Poisson process, queuing processes, power spectral densities, Gaussian random process. Response of linear systems to random signals. Elements of estimation and inference as they arise in communications and digital signal processing systems. Extra homework problems, team homework disallowed, higher expectations for mini-projects.
Enrollment Information: Enrollment limited to: graduate students.
Recommended prerequisite: ECE 2720, ECE 3100, and ECE 3250 or equivalents.
Last Four Terms Offered: Spring 2026, Fall 2025, Fall 2024, Fall 2023
Learning Outcomes:

- Knowledge of a variety of mathematical models for random phenomena.
- Ability to classify models with respect to stationarity, Markov property, asymptotics, and more.
- Ability to make optimal inferences and estimates with respect to such criteria as minimum error probability, and minimum mean square error.
- Become aware of applications to communications, machine learning, statistical physics and more.
- Response of linear systems to random process inputs (time permitting).

Schedule of Classes (https://classes.cornell.edu/)

ECE 5120 - Model Based Systems Engineering (4 Credits)
Crosslisted with SYSEN 5100, CEE 5240, ORIE 5140, MAE 5910
Fundamental ideas of systems engineering, and their application to design and development of various types of engineered systems. Defining system requirements, creating effective project teams, mathematical tools for system analysis and control, testing and evaluation, economic considerations, and the system life cycle.Content utilizes model-based systems engineering, which is the integration of systems modeling tools, such as SysML, with tools for systems analysis, such as Matlab and Modelica. The vision for this integration is the ability to create and analyze complete parametric representations of complex products and systems. These systems make it possible to investigate the impact of changing one aspect of a design on all other aspects of design and performance. This course will familiarize students with these modeling languages. Off-campus students must provide their own Windows 7, internet-connected, computer with administrator access in order to install the commercial software used in this course.
Prerequisites: Prerequisite or corequisite: enrollment in group-based project with strong system design component approved by course instructor.
Enrollment Information: Enrollment limited to: seniors or graduate students in an engineering field.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5130 - Systems Analysis Behavior and Optimization (3 Credits)
Crosslisted with SYSEN 5200, CEE 5252, MAE 5920, ORIE 5142
This is an advanced course in the application of analytical methodologies and tools to the analysis and optimization of complex systems. On completion of this course, students should be able to use probability and statistics as a modeling and analysis tool for systems exhibiting uncertainty; be able to use algorithms and dynamic programming to model and optimize systems with a recursive structure; be able to use optimization tools to optimize complex systems and tune parameters.
Prerequisites: ENGRD 2700, calculus skills, and familiarity with basic programming in a language such as python, C++, java, matlab, etc.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 5160 - Fast Robots (4 Credits)
Crosslisted with MAE 5190
The course focus is on systems level design and implementation of fast and dynamic autonomous robots. With the recent DIY movement, design of kinematic robots is largely becoming a software challenge. In dynamic robots, however, any latency or noise can be detrimental. We will design a fast autonomous car, explore dynamic behaviors, acting forces, sensors, and reactive control on an embedded processor, as well as the benefit of partial off-board computation. Students will learn how to derive design specifications from abstract problem descriptions and gain familiarity with rapid prototyping techniques, system debugging, system evaluation, and online dissemination of work.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students will learn how to robustly integrate systems consisting of electronics, software, and mechanics operating in the real world.
- Students will learn how to translate probabilistic control and planning methods to practical robots with hardware and processing constraints.
- Students will learn how to disseminate their work to their peers and an engineering audience.
- Students will learn how to predict the likely social and environmental effects of their design.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5200 - Foundations Machine Learning (4 Credits)
This is an introductory course in machine learning (ML) that covers basic theory, algorithms, and applications. The class will develop a principled understanding of the various facets of ML and encompass fundamental (supervised and unsupervised) ML primitives that underpin modern technologies. Specifically, the learning theory content will cover the statistical learning paradigm, empirical risk minimization, generalization, bias-variance tradeoff, regularization, and validation. The supervised learning chapter will cover regression, the maximum likelihood principle, generalized linear models, support vector machines, and naïve Bayes. Unsupervised learning methods will include clustering, k-means, EM algorithm, factor analysis, and other dimensionality reduction techniques. The final few lectures will be devoted to large language models and the generative pre-trained transformer (GPT) architecture, as well as topics in ethics and fairness in machine learning. Our treatment of the material will start from theoretical principles, and build up towards implementation and applications dealing with text data, handwriting, music, images, etc. To that end, the course will incorporate a programming.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025
Schedule of Classes (https://classes.cornell.edu/)

ECE 5210 - Network Systems and Games (3 Credits)
Network systems pervade our society in both social and technological contexts. On the one hand, social networks play a central role in the transmission of information and viruses with fundamental consequences for product marketing, technology adoption, voting decisions, spread of false news and epidemiology. On the other hand, network topology fundamentally affects the performance and resilience properties of large-scale multi-agent systems, such as the electric power grid, the internet of things, traffic or robotic sensor networks.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 5235 - Sustainable Urban and Energy Delivery Systems (3 Credits)
Crosslisted with INFO 5235, ORIE 5235
The course focuses on how to transition from legacy energy delivery infrastructures dependent on fossil fuel to a sustainable decarbonized grid that harnesses distributed renewable energy resources and responsive demand from buildings, electrified transportation systems, and industrial loads. The content includes models and abstractions for the architecture of the cyber-physical energy system, its economics, and future evolution, and numerical optimization and learning methods in support of the infrastructure's safety critical operations in the legacy system and in the future architecture. At the MSc level the students will focus on learning how to use tools and data while at the graduate level the students will be asked to also solve problems, formulate novel solutions, interpret results. Similarly, to differentiate the MSc from PhD level and course outcomes, the final project will require the MSc students to pick one out of a set of predefined problems while the PhD students will have to define an original problem and solution.
Prerequisites: coursework in ML, data science, law and policy or ethics, calculus and algebra, algorithms, and python programming. Recommended prerequisite: coursework in theory and optimization.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Spring 2023
Learning Outcomes:

- Students will be able to identify technical and operational models for energy delivery systems and appreciate why energy consumption in urban environments is bound to continue to be the most significant source of emissions under the status quo.
- Students will learn about and analyze emerging technological solutions in wide area sensing and IoT networks, machine learning and decision models that support the coordination the distributed renewable resources on the supply side with the flexible demand of electricity in urban environments.
- Students will identify security challenges that are unique of cyber-physical infrastructures and need to be addressed to advance to rip the benefits of digital technology in the field.
- Through assignments and projects, the students will gain hands-on experience in demonstrating on how to apply novel data models, network technology and software tools that encompass the various topics covered in the class.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5240 - Robot Perception (3 Credits)
Crosslisted with MAE 5810
An introductory course to robot perception techniques for modeling and planning heterogeneous and dynamic sensor measurements, and for processing the sensor feedback in the context of robot motions and environments. Methods for intelligent sensor fusion and robot perception in motion will be covered in detail in this course. Topics in artificial vision, acoustic propagation, and filtering will be discussed along with related algorithms inspired by neural networks, Bayesian networks, and information theory. Sensing problems and performance will be investigated in regard to benchmark problems, such as coverage, target search, target tracking, and treasure hunting, will be covered in-depth and demonstrated through applications drawn from environmental monitoring, sensing-and-pursuit games, surveillance, and human-robot interactions.
Prerequisites: ENGRD 2112, MATH 2940, and MATH 4710 (or ENGRD 2700 or ENGRD 2720); or graduate standing in a technical field.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021
Learning Outcomes:

- Students will be able to use methods for sensor fusion to inform robot perception.
- Students will be able to implement artificial vision, acoustic propagation, and filtering along with neural networks, Bayesian algorithms, and information theory to identify robot states.
- Students will be able to analyze benchmark problems such as coverage, target search, target tracking, and treasure hunting.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5242 - Intelligent Autonomous Systems (3 Credits)
How can intelligent machines perceive, make decisions, and execute their plans in an uncertain, dynamic world? This course will cover methods and algorithms for sensory perception, planning, and control with a focus on real-time adaptation and learning. Students should have prior experience with data processing and machine learning methods. Topics covered include probabilistic methods for sensory integration, latent models for dynamical systems, navigation and reinforcement learning. Students will learn about fundamental principles underlying algorithms for intelligent systems as well as how to implement these algorithms for real-time processing.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2026, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5245 - Digital Fabrication: Manipulating the Matter of Tech (3 Credits)
Crosslisted with INFO 5380
Historically, computing encompassed one-dimensional Input/Output using command line interfaces. The GUI and mouse brought 2D I/O to computing, and later VR and 3D Scanning allowed for 3D I/O. The next thing is interacting with matter as I/O for computing: Digital Fabrication. This course teaches fabrication techniques, and how to leverage it to control physical matter. This will allow you to develop hardware or understand how to talk to hardware developers within your team. We will dive down to the bare bones of fabrication machines by creating custom slicers to control 3D printers using basic coding. We will take apart existing products to study how they were made and build entirely new products from scratch.
Last Four Terms Offered: Spring 2026, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 5250 - Digital Signal Processing and Statistical Inference (4 Credits)
This course introduces discrete-time signal and system models in deterministic and stochastic settings and develops signal processing and statistical inference methodologies for real-time sensing and control applications. The course is intended for upper-level undergraduate and beginning graduate engineering students in engineering departments.The course covers both deterministic and stochastic techniques. Specific topics include time and frequency domain representation of signals and systems, state-space representation, feedback, stability, linear and nonlinear filtering, signal and state estimation and tracking, hypothesis testing, and signal detection. Applications in communications and control system design are integrated into the course material.ECE5250 co-meets with ECE4250. The lecture part of the two courses is the same. The homework, projects, and exams are different for the two courses. Students taking ECE5250 are given extra homework problems and project assignments to gain a deeper analytical understanding of the material.
Prerequisites: MATH 1920 and MATH 2940, ECE 3100 or equivalent course that satisfies ECE probability requirements, ECE 2720 and ECE 3250 or equivalent courses.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Be able to obtain impulse response from frequency and state-space models and vice versa. Be able to analyze system stability, reachability, and observability given a linear time-invariant state space model.
- Be able to design and implement state and observer-based feedback systems that stabilize an unstable system.
- Be able to understand stationary and wide-sense stationary models of discrete-time signal and the notion of power spectrum density of a wide-sense stationary process.
- Be able to solve signal estimation and detection problems under parametric and state-space models, including implementing Wiener and Kalman filtering techniques for estimation, and using matched filtering in signal detection.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5260 - Graph-Based Data Science for Networked Systems (3 Credits)
Crosslisted with ORIE 5735
The goal of this course is to introduce data structural and computational models that are indexed by the irregular support of a graph. The graph represents the network that couples the dynamics of many agents, or it can be a more abstract Bayesian graphical model that explains how observations are conditionally dependent. The course will start from introducing basic concepts in graph theory followed by an introduction to random graphs models. This part will be followed by network dynamical models that model the observations from these processes. Bayesian graphical models will be briefly covered as a more general statistical abstraction and computational framework to perform inferences. The course will then introduce the students to the emerging field of graph signal processing, a theory that generalizes digital and image processing to graph signals.
Enrollment Information: Enrollment limited to: Cornell Tech students. Recommended prerequisite: linear algebra, probability theory, basic python or MATLAB programming skills.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Fall 2022
Learning Outcomes:

- Students will be able to identify the type of data that are amenable to be the outcome of network dynamical models or Bayesian graphical network models exemplified in the course or a generalization of the ones covered.
- Students will be able to understand the difference between these kinds of multivariate data compared to time-series or images.
- Students will be able to analyze the data to predict and infer data trends, for a given model.
- Students will be able to analyze the data to learn the latent network structure and system parameters.
- Students will be able to demonstrate and document the data analysis performance on synthetic and on real data.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5280 - Optimal System Analysis and Design (4 Credits)
Introduction to optimization theory and algorithms for system analysis and design. Topics include linear programming, convex programming, duality. We may touch dynamic programming around the end if time permits. Application will be discussed in various areas including geometric problems, networks, control, circuits, signal processing, and communications. This course is ideal for students who have not had an optimization course but want to have an idea of the subject within one semester.Added final project.
Prerequisites: ECE 3250, MATH 1920, MATH 2940.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 5290 - Distributed Optimization for Machine Learning and AI (3 Credits)
Crosslisted with ORIE 5290
This is a graduate-level course about theory, algorithms and applications of distributed optimization and machine learning. The course covers the basics of distributed optimization and learning algorithms and their performance analyses when they are used to solve large-scale distributed problems arising in AI, machine learning, signal processing, communication networks, and power systems.
Last Four Terms Offered: Fall 2025
Learning Outcomes:

- Be able to formulate optimization problems arising from machine learning, signal processing, and wireless communication tasks.
- Be able to implement numerically stable and scalable algorithms to solve practical optimization problems in large-scale learning and computing.
- Be able to quantify convergence rates and resource efficiency of optimization algorithms in terms of iteration, computation and communication counts.
- Be able to design, modify, and deploy optimization algorithms tailored to the structure and constraints of real-world learning and wireless computing systems. (For PhD students)

Schedule of Classes (https://classes.cornell.edu/)

ECE 5320 - Integrated Micro Sensors and Actuators: Bridging the Physical and Digital Worlds (4 Credits)
Introduction to micro and nano devices that allow the digital world to both sense and actuate in the physical world. Design and analysis of modern MEMS/NEMS (Micro/Nano Electromechanical Systems) touch, accelerometers, gyroscopes, pressure, microphones, neural probe sensors. Design and analysis of electrostatic, piezoelectric, thermal, and magnetic actuators for frequency control and micro robotic applications. This is an interdisciplinary course drawing from mechanics, materials, solid state devices, CMOS electronics, and micro and nano fabrication. The students design, fabricate, and test a microsensor chip to implement class concepts.
Prerequisites: ECE 2100 or equivalent, or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Fall 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Be able to design and model a digital app-based electronic interface to integrated sensors.
- Be able to model spring-mass equivalent models of micro/nano fabricated structures, using analysis and finite-element analysis software.
- Be able to use individual fabrication steps into a device fabrication process flow.
- Be able to design and model electromechanical models of planar surface micromachined accelerometers and gyroscopes.
- Be able to design membrane based sensors and actuators such as pressure monitors and microphones.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5330 - Quantum Physics and Engineering (4 Credits)
Introduction to quantum physics and engineering for advanced undergraduate and beginning graduate students. Topics covered include historical developments, quantum postulates, Schrodinger equation, quantum states and observables, measurement in quantum mechanics, quantum confined states in potential wells and atoms, quantum tunneling, uncertainty relations, Dirac notation, angular momentum and spin, quantum dynamics, time-independent and time-dependent perturbation theories, quantum two-level systems, quantum information and the qubit, quantum computation and quantum circuits, identical particles, quantum statistics for fermions and bosons, fundamentals of quantum statistical physics, quantization of light and the photon, quantization of simple mechanical and electrical superconducting circuits. The course will enable students to take advanced courses in areas related to electronic and optical devices, solid state physics and material science, and quantum information and computation.More advanced homework; added term paper.
Prerequisites: PHYS 2214, MATH 2930, or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5340 - Photonics: Fundamentals and Devices (3 Credits)
Introduction to optical waveguides and photonic devices. Review of optical wave propagation in uniform media and at interfaces. Gaussian beams and diffraction. Modes, dispersion, and fundamental relations/symmetries. Interferometers and resonators. Guided waves in optical fibers and planar dielectric systems. Perturbation theory, coupling of modes, adiabatic variation, and parallels to quantum phenomena. Electro- and acousto-optics. Survey of system applications, including photonic interconnects and quantum technologies. Numerical methods, and project design of planar optical components.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students will learn about optical wave propagation in structured media.
- Students gain an understanding of modes, modal coupling, and application in photonic devices.
- Students will learn about active electro-and acousto-optic devices and their applications.
- Students will analyze, simulate, and design planar photonic components.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5350 - Semiconductor Physics (4 Credits)
Covers basic solid state and semiconductor physics relevant for understanding electronic and optical devices. Topics include crystalline structures, bonding in atoms and solids, energy bands in solids, electron statistics and dynamics in energy bands, effective mass equation, carrier transport in solids, Boltzmann transport equation, semiconductor homo- and hetero-junctions, optical processes in semiconductors, electronic and optical properties of semiconductor nanostructures, semiconductor quantum wells, wires, and dots, electron transport in reduced dimensions, semiconductor lasers and optoelectronics, high-frequency response of electrons in solids and plasmons.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
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ECE 5360 - Semiconductor Electronic and Photonics Devices (4 Credits)
Crosslisted with MSE 5445
The class develops the fundamentals of semiconductor electronic and photonic devices that power to-day's computation, communication, and memory industries. It relates the basics of pn junctions to their applications in solar cells, light emitting diodes, and lasers. Majority and minority carrier transport in heterostructure bipolar transistors is related to gain and speed limits of amplifiers for 5G communications and beyond. Schottky diodes and their applications in power electronics, and in field effect transistors of many flavors ranging from Silicon CMOS and FinFETs to GaN high electron mobility transistors are covered. Tunneling transport, flash memory, and DRAM devices are discussed. The course uses industrially relevant simulation tools, and the laboratory component gives students firsthand experience of measuring and appreciating the power and the limitations of semiconductor devices, and the reason for their revolutionary influence on our lives and society. MEng students and ECE PhD students who enroll in the 5000 level will be required to complete one extra design laboratory project compared to the 4000 level class.
Prerequisites: ECE 3150 or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023
Learning Outcomes:

- Obtain a well-grounded understanding of semiconductor device operation and advanced ideas in use in microelectronic industry and future generations of electronic circuitry.
- Learn through simulations, the aspects of physical behavior that analytic solutions are incomplete at and their more complete description of operational physics.
- Apply device fundamentals and simulation techniques to design modern nanoscale device structures.
- Develop comprehensive skills straddling electronics, integration, and devices as used in integrated circuits leading to effective communication of results.

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ECE 5380 - Electromagnetic and Optical Metamaterials (3 Credits)
Introductory Senior-level course on electromagnetic and optical metamaterials. The properties of matter can be molded and tailored on subwavelength spatial scales yielding 'metamaterials' with properties very different from naturally occurring materials, thereby opening up new directions for applications. The course introduces the electromagnetic and optical properties of surface plasmons and polaritons, artificial magnetic materials, negative-index materials, nanostructured optical materials, etc. The course also discusses the applications of these materials in diverse areas including electromagnetic cloaking and invisibility, stealth technologies, optical super-lensing, bio-chemical sensing, conformal optics, meta-surfaces, and non-reciprocal devices.
Prerequisites: ECE 3030 or AEP 3550 or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5413 - Developing and Designing Interactive Devices (3 Credits)
Crosslisted with INFO 5345, CS 5424
This course covers the human-centered and technical workings behind interactive devices ranging from cell phones and video game controllers to household appliances and smart cars. This is a hands-on, lab-based course. For the final project, students will build a functional IoT prototype of their own design, using Python, single-board Linux computer, embedded microcontrollers, and/or other electronic components. Topics include electronics prototyping, interface design, sensors and actuators, microcontroller development, physical prototyping, and user testing.
Prerequisites: CS 1110 or equivalent.
Last Four Terms Offered: Fall 2025, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 5414 - Applied Machine Learning (3 Credits)
Crosslisted with CS 5785, ORIE 5750
Learn and apply key concepts of modeling, analysis and validation from machine learning, data mining and signal processing to analyze and extract meaning from data. Implement algorithms and perform experiments on images, text, audio and mobile sensor measurements. Gain working knowledge of supervised and unsupervised techniques including classification, regression, clustering, feature selection, and dimensionality reduction.
Prerequisites: CS 2800 or equivalent and basic familiarity with Matlab or Python, or permission of instructor.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5415 - Digital Signal Processing and Learning (3 Credits)
This course covers fundamentals of digital signal and image processing (DSP); and its connections to modern machine learning, using a balanced mix between math and hands-on experiments. The course will teach basic concepts in signals and systems, including convolutions, frequency analysis, sampling, compressed sensing, image segmentation, image registration, neural network-based machine learning, and representation learning. We will use multiple hands-on programming assignments to demonstrate the concepts we cover in class and problem sets that will help students practice with the theory. A background in linear algebra and probability will be critical to follow the theoretical concepts. All coding will be done in Python. We will offer supplementary material to help get started with Python coding and reinforce the background in linear algebra and probability.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
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ECE 5420 - Fundamentals of Machine Learning (4 Credits)
The course will be devoted to understanding, implementation, and applications of various machine learning primitives. This course is intended to have three modules, and within each we will cover basic theory, and implementations. The modules will be supervised learning, unsupervised learning, and finally topics that are motivated by engineering applications such as speech recognition, and recommendation systems. Supervised learning will include regression, support vector machines, decision trees, random forests, naive Bayes, boosting and bagging. Unsupervised learning includes clustering, k-means, k-NN, principal components analysis and other dimensionality reduction methods. We will give particular emphasis on engineering applications, e.g., text data, hand-writing, music, image, and time series data, and categorical datasets such those in recommendation systems. The course will have a programming component, which will be administered in the form of assignments, and in-class-kaggle competitionExtra homework problems, report required for projects.
Prerequisites: MATH 2940, ECE 3100 or STSCI 3080 or ECE 3250 or equivalents.
Forbidden Overlaps: CS 3780, CS 5780, ECE 3200, ECE 5420, ORIE 3741, ORIE 5741, STSCI 3740, STSCI 5740
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2024, Spring 2023, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 5470 - Computer Vision (3 Credits)
Covers computer acquisition and analysis of image data with emphasis on techniques for robot vision. Concentrates on descriptions of objects at three levels of abstraction: segmented images (images organized into subimages that are likely to correspond to interesting objects), geometric structures (quantitative models of image and world structures), and relational structures (complex symbolic descriptions of images and world structures). The programming of several computer-vision algorithms is required.
Prerequisites: ECE 2720 or equivalent or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 5510 - Electric Power Systems I (3 Credits)
Acquaints students with modern electric power system modeling, analysis and computation. Stresses analysis techniques appropriate for power system modeling, analysis and power flow computation. Topics include transmission line models, transformers and per unit system, generator models, network matrices, power flow analysis and computation, real and reactive power control, voltage control, economic dispatch.Added homework, added design project.
Prerequisites: ECE 3250.
Enrollment Information: Enrollment limited to: graduate students.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Knowledge of a variety of mathematical models for power system components.
- Ability to classify such models as to issues of static model and dynamic model.
- Ability to make optimal inferences with respect to such criteria as minimum production cost and minimum emission (power flow and economic dispatch). Elements of optimal design are introduced.
- Response of power flow, bus voltage to power demand variations as well as power injection variations.
- Response of power system static behaviors to power system contingencies (such as line outages, transformer outages, generator tripping and huge load variations).

Schedule of Classes (https://classes.cornell.edu/)

ECE 5530 - Analog Integrated Circuit Design (4 Credits)
Overview of devices available to analog integrated-circuit designers in modern CMOS and BiCMOS processes: resistors, capacitors, MOS transistors, and bipolar transistors. Basic building blocks for linear analog integrated circuits: single-stage amplifiers, current mirrors, and differential pairs. Transistor-level design of linear analog integrated circuits, such as operational amplifiers and operational transconductance amplifiers. Layout techniques for analog integrated circuits. Throughout the course, emphasis is placed on design-oriented analysis techniques.More extensive lab requirements.
Prerequisites: ECE 3150.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Develop an understanding of device and circuit theory sufficient to estimate the low and high frequency behavior of linear circuits, including noise.
- Develop an intuition for analog circuit behavior in both linear and nonlinear operation.
- Be able to calculate transfer functions and Bode plots and use them to estimate the stability of an electronic system.
- Develop an ability to parse large circuits and systems into smaller, analyzable subunits, analyze them, and then apply the understanding gained from that process to analyze the system as a whole, including for noise and variation.
- Implement a circuit or subsystem at the transistor level to solve an open-ended problem and effectively communicate the constraints and critical aspects of that system.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5545 - Machine Learning Hardware and Systems (3 Credits)
Crosslisted with CS 5775
This Master's level course will take a hardware-centric view of machine learning systems. From constrained embedded microcontrollers to large distributed multi-GPU systems, we will investigate how these platforms run machine learning algorithms. We will look at different levels of the hardware/software/algorithm stack to make modern machine learning systems possible. This includes understanding different hardware acceleration paradigms, common hardware optimizations such as low-precision arithmetic and sparsity, compilation methodologies, model compression methods such as pruning and distillation, and multi-device federated and distributed training. Through hands-on assignments and an open-ended project, students will develop a holistic view of what it takes to train and deploy a deep neural network.
Enrollment Information: Enrollment limited to: Cornell Tech students. Recommended prerequisite: undergraduate ECE/CS degree, programming experience, introductory ML course.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Understand how machine learning algorithms run on computer systems. This includes both the hardware and the software that maps computations onto the computer chips.
- Apply key optimization techniques such as pruning, quantization and distillation to machine learning algorithms to improve their efficiency on different hardware platforms.
- Analyze the performance and efficiency of different hardware platforms with and without optimizations, and understand the impact of efficiency optimizations on the accuracy of a machine learning algorithm.
- Design both the hardware and software components of a machine learning computer system.

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ECE 5560 - Power Electronics (4 Credits)
Power electronics is an enabling technology for sustainable and energy efficient systems, as all renewable energy sources (including solar and wind) and efficient electrical loads (including LED lighting and electric vehicles) require a power electronic converter to interface them with the electrical grid. Power electronic converters, being inherently non-linear/time-variant circuits, cannot be analyzed using linear time-invariant (LTI) circuit analysis techniques, nor conventional small-signal linearization techniques taught in introductory circuits (ECE 2100) and microelectronics (ECE 3150) courses. This course, which will follow ECE 3150, will introduce advanced circuit analysis and modeling techniques required to predict the steady-state and dynamic behavior of power electronic converters. The course will also introduce seniors and first-year graduate students to other advanced topics which are required for the analysis and design of power converters, including power semiconductor device modeling, thermal modeling, magnetic component modeling, electromagnetic interference (EMI) filter design, and switching converter control design, at a level appropriate for them. This course will equip ECE students with the theoretical and practical skills needed to innovate in the area of power electronics, and allow them to succeed in graduate school and in the rapidly growing job market for power electronic engineers.Added final project.
Prerequisites: ECE 3150 or permission of instructor required.
Enrollment Information: Enrollment limited to: graduate students.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5570 - Microwave Circuit Design (4 Credits)
This course covers techniques to design and analyze microwave circuits. These techniques, in general, can be used for electrical devices with dimensions in the order of the operating wavelength. These devices are commonly used in RF/mm- wave wireless communication systems, quantum computing/sensing systems, and electromagnetic imaging/radar systems. Topics include planar transmission lines, network analysis, S-parameters, matching networks, resonators, power dividers/combiners, filters, and non-reciprocal devices. The course emphasizes physical understanding, intuitive design methods, and hands-on experience in using E+M simulation tools and microwave measurements.
Prerequisites: ECE 3030 and ECE 3150.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023
Learning Outcomes:

- Analyze important building blocks in microwave/millimeter wave systems.
- Design and optimize microwave components and understand the challenges in high operating frequency.
- Develop the ability to use E+M circuit simulators and perform microwave measurements.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5620 - Fundamentals of Data Compression (3 Credits)
Fundamental limits and practical algorithms for data compression. Entropy and other information measures. Variable and ?xed-length lossless and lossy source codes. Universal compression. Single-source and network con?gurations. Applications to text and multimedia compression.
Prerequisites: ECE 4110 or equivalent.
Last Four Terms Offered: Fall 2024, Spring 2021, Spring 2019, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

ECE 5660 - Computer Networks and Telecommunications (3 Credits)
This is a senior-level course in information networking with an emphasis on wireless technology. Examples of topics include: 5G cellular, the latest WiFi standards, Bluetooth, routing and switching, congestion control, network security, and user privacy. Though the focus will be on communication networking technologies, downstream legal and social issues that arise from design decisions will be discussed. Added midterm, longer final report, more advanced homework.
Prerequisites: ECE 3100.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Knowledge and understanding of how modern cellular technology, the Internet and other prominent technologies reached their current form.
- Ability to understand and analyze basic important algorithms in the Internet, such as congestion control and shortest path routing.
- Be able to understand the challenges that come with designing wireless networks and the tradeoff of corresponding solutions.
- Understand the limitation of current wired and wireless architectures. Be able to perform related analysis and design, and to predict future emphases as these technologies evolve.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5670 - Digital Communications (4 Credits)
Principles of modeling communication baseband and passband channels. Methods for communicating in the presence of intersymbol interference, noise, channel uncertainty, and asynchrony. Design, in software, of a transmitters and receivers to communicate over audio-band and RF channels.
Prerequisites: ECE 3250, ECE 4110.
Forbidden Overlaps: ECE 4670, ECE 5670
Enrollment Information: Enrollment limited to: Engineering students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 5690 - Radio Frequency Systems (3-4 Credits)
This course addresses the design of radio-frequency links in the component view to enable eventual full-duplex, multi-access wireless network. The analysis will reside mostly in the signal (SIMULINK) level instead of the circuit implementation, although the nonideal circuit characteristics will be reflected in the signal representation. Federal Communications Commission (FCC) and Occupational Safety & Health Administration (OSHA) standards will be introduced. Existing standard protocols will be selectively introduced including FM, TV broadcast, Bluetooth, Z-wave, Zigbee and Wi-fi to enable intuitive understanding of RF system tradeoffs.Added design project.
Prerequisites: ECE 3030 or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 5710 - Datacenter Computing (4 Credits)
The course provides a strong foundation for students to understand the entire system stack in cloud computing systems today, from hardware to OS, resource management, and application frameworks, as well as considerations such as reliability, privacy, and security. The course consists of a mix of lectures and discussions of the latest papers in datacenter design and management. Topics include, but are not limited to: server design, hardware accelerators, cloud OS, cluster management, distributed programming frameworks, microservices, serverless computing, and cloud security and privacy.
Prerequisites: ECE 4750 or CS 4410 or equivalent courses, or instructor permission.
Last Four Terms Offered: Spring 2022, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 5720 - Introduction to Parallel Computing (3 Credits)
Last Four Terms Offered: Spring 2022, Spring 2021, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 5725 - Design with Embedded Operating Systems (4 Credits)
Design of microcontroller based systems using embedded Linux. Student teams design and debug example solutions on a target microcontroller (for example, Raspberry Pi) during lab sessions. Emphasis will be on application and Linux programming skills, processor and microcontroller architecture with some discussion of hardware interfaces. Students create a final, end-of-semester project using the microcontroller platform and development techniques discussed during the semester.
Prerequisites: ECE 3140/CS 3420.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 5727 - Embedded Systems Laboratory (1 Credit)
This Master's level laboratory course covers how to interface real world sensors and actuators to embedded microprocessor systems. Concepts needed for building electronic systems for real-time operation and user interaction, such as digital input/outputs, analog-to-digital conversion, interrupt service routines, communications, and event-driven programming will be covered. The course will conclude with a student-designed final project demonstration and presentation.
Prerequisites: programming experience.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 5730 - Digital Systems Design Using Microcontrollers (4 Credits)
Design of real-time digital systems using microprocessor-based embedded controllers. Students working in pairs design, debug, and construct several small systems that illustrate and employ the techniques of digital system design acquired in previous courses. The content focuses on the laboratory work. The lectures are used primarily for the introduction of examples, description of specific modules to be designed, and instruction in the hardware and high-level design tools to be employed.Added requirements for each lab.
Prerequisites: ECE 3140/CS 3420.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Spring 2025, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5740 - Computer Architecture (4 Credits)
This course aims to provide a strong foundation for students to understand modern computer system architecture and to apply these insights and principles to future computer designs. The course is structured around the three primary building blocks of general-purpose computing systems: processors, memories, and networks. The first half of the course focuses on the fundamentals of each building block. Topics include processor microcoding and pipelining; cache microarchitecture and optimization; and network topology, routing, and flow control. The second half of the course delves into more advanced techniques and will enable students to understand how these three building blocks can be integrated to build a modern shared-memory multicore system. Topics include superscalar execution, branch prediction, out-of-order execution, register renaming and memory disambiguation; VLIW, vector, and multithreaded processors; memory protection, translation, and virtualization; and memory synchronization, consistency, and coherence. This course includes a significant project decomposed into five lab assignments. Throughout the semester, students will gradually design, implement, test, and evaluate a complete multicore system capable of running real parallel applications at the register-transfer level.Added problem set and added lab.
Prerequisites: ECE 3140/CS 3420 or CS 3410. Students should feel comfortable working with a hardware description language such as Verilog, SystemVerilog, or VHDL.
Enrollment Information: Enrollment limited to: ECE or CS graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Describe computer architecture concepts and mechanisms related to the design of modern processors, memories, and networks and explain how these concepts and mechanisms interact.
- Apply this understanding to new computer architecture design problems within the context of balancing application requirements against technology constraints; more specifically, quantitatively assess a design's execution time in cycles and qualitatively assess a design's cycle time, area, and energy.
- Evaluate various design alternatives and make a compelling quantitative and/or qualitative argument for why one design is superior to the other approaches.
- Demonstrate the ability to implement and verify designs of varying complexity at the register-transfer-levels.
- Create new designs at the register-transfer-level and the associated effective testing strategies.
- Write concise yet comprehensive technical reports that describe designs implemented at the register-transfer-levels, explain the testing strategy used to verify functionality, and evaluate the designs to determine the superior approach.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5744 - Introduction to Digital (VLSI) Design (4 Credits)
This graduate-level course provides an introduction to digital very large-scale integration (VLSI) design from architectural considerations down to the layout level. Lecture, labs, and homework topics emphasize disciplined synchronous VLSI design and include topics of CMOS logic, layout, and timing; computer-aided design and analysis tools; electrical and performance considerations.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Quantitatively evaluate CMOS technology parameters for digital applications.
- Design digital circuit modules at the module timing, circuit schematic and layout levels.
- Perform digital circuit simulation and verification in the CAD software.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5746 - Applied Digital ASIC Design (3 Credits)
This course introduces contemporary design of digital very-large scale integration (VLSI) circuits and hands-on experience in digital VLSI design using state-of-the-art computer aided design (CAD) tools. The lectures will cover FinFET CMOS technology and scaling, design principles of core VLSI building units, including arithmetic circuits, sequential circuits, memory system, I/O circuitries, etc. Students will learn how digital VLSI implementations in CMOS are overarched by considerations of key design metrics, such as timing, power, area, and reliability. The lab assignments provide hands-on experience on how to implement a given algorithm onto an application specific integrated circuit (ASIC), progressively going through the processes of hardware description language (HDL) coding on register transfer level (RTL), synthesis, automatic place-and-route, and post-layout verification processes (i.e. overall RTL-to-GDS flow). For the lab assignment, the process design kit and standard cell / memory libraries of TSMC 16nm ADFP (Academic Design Foster Package) will be used.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 5755 - Modern Computer Systems and Architecture (3 Credits)
Crosslisted with CS 5754
This Master's level course is designed to provide a hardware-centric overview of computer systems used in modern computing platforms. From the bottom up we will study the architecture of processor architectures (e.g., pipelined CPUs, ISA, RISC vs. CISC, out-of-order execution) and memory systems (e.g., memory hierarchy, caching, DRAM memories). We will understand how to evaluate the performance of modern processors and exploit parallelism in applications. This includes parallelization across multi-core CPUs, GPUs, and specialized hardware. Through ands-on assignments and an open-ended project students will develop a holistic understanding of modern computer systems and how they are designed.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023
Learning Outcomes:

- Demonstrate an understanding of micro-architectural principles foundational computer architectures including processor pipelines, caching and memory systems, multi-core designs.
- Demonstrate an understanding of modern computer systems such as software parallelization strategies (e.g., ILP, TLP, DLP), hardware accelerators (e.g., GPUs, FPGAs, ASICs), and modern mobile and datacenter scale systems.
- Demonstrate the ability to analyze performance bottlenecks of software applications running on hardware platforms and optimize systems to maximize performance and efficiency.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5760 - Hardware Acceleration via FPGA (4 Credits)
Design of system-on-chip applications. Students working in pairs design, debug, and construct several systems that illustrate the design of embedded processors with custom peripherals running a real-time operating system. The content focuses on laboratory work. The lectures are used primarily for the introduction of examples, description of specific modules to be designed, and instruction in the hardware and high-level design tools to be employed.
Prerequisites: Recommended prerequisite: ECE 5725.
Last Four Terms Offered: Spring 2026, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5772 - Autonomous Mobile Robots (4 Credits)
Crosslisted with MAE 5180, CS 5758
Creating robots capable of performing complex tasks autonomously requires one to address a variety of different challenges such as sensing, perception, control, planning, mechanical design, and interaction with humans. In recent years many advances have been made toward creating such systems, both in the research community (different robot challenges and competitions) and in industry (industrial, military, and domestic robots). This course gives an overview of the challenges and techniques used for creating autonomous mobile robots. Topics include sensing, localization, mapping, path planning, motion planning, obstacle and collision avoidance, and multi-robot control.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand and implement localization and mapping algorithms using different sensor modalities.
- Students will be able to generate a path and the motion for a robot moving around an area with obstacles.
- Students will be able to understand and implement the concepts of different approaches for motion planning such as roadmaps, feedback control, and sampling based methods.
- Students will be able to apply the tools learned in the class to physical robots.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5810 - Introduction to Plasma Physics (4 Credits)
Crosslisted with AEP 6060, EAS 5810
Topics include plasma state; motion of charged particles in fields; drift-orbit theory; coulomb scattering, collisions; ambipolar diffusion; elementary transport theory; two-fluid and hydromagnetic equations; plasma oscillations and waves, CMA diagram; hydromagnetic stability; and elementary applications to space physics, plasma technology, and controlled fusion.
Enrollment Information: Enrollment limited to: graduate students and exceptional seniors. Recommended prerequisite: ECE 3030 or equivalent.
Last Four Terms Offered: Fall 2025, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 5815 - Introduction to Nuclear Science and Engineering (3 Credits)
Introduces the fundamental concepts of nuclear science and engineering, including nuclear structure, radioactivity, nuclear reactions and the interaction of neutrons, charged particles, x-rays and gamma-rays with matter. Discusses the neutron chain reaction and its control in the core of a fission reactor. Different reactor designs are introduced and discussed along with their safety features. Other topics include radiation shielding and aspects of the nuclear fuel cycle, including isotope separation, fuel reprocessing, waste disposal and sustainability.
Prerequisites: MATH 1920, MATH 2930, PHYS 2213, PHYS 2214, or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023
Learning Outcomes:

- Demonstrate basic conceptual understanding of atomic and nuclear physics, quantum mechanics and electrostatics relevant to the interaction of radiation with matter, and especially neutron interactions.
- Demonstrate a basic understanding of the fission process and neutron chain reactions.
- Know and understand the advantages and disadvantages of various combinations of fuel and other materials (moderator, coolant, structure) for safety and sustainability.
- Understand the design and operation of a nuclear reactor core as a critical or near critical mass of fissile and other materials in steady state and in times of slowly changing power.
- Demonstrate the ability to calculate the amount of fuel needed by a power reactor per year as well as the amount of nuclear waste that will be produced and its decay rate.
- Know and understand the interaction of radiation with biological systems and the consequences thereof, and methods of shielding to reduce radiation effects.
- Understand case histories of nuclear reactor accidents.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5840 - Introduction to Controlled Fusion: Principles and Technology (3 Credits)
Introduction to the physical principles and various engineering aspects underlying power generation by controlled fusion. Topics include: fuels and conditions required for fusion power and basic fusion-reactor concepts, fundamental aspects of plasma physics relevant to fusion plasmas and basic engineering problems for a fusion reactor, and an engineering analysis of proposed magnetic and/or inertial confinement fusion-reactor designs.
Prerequisites: one of the following: PHYS 1112, PHYS 2213, PHYS 2214, or equivalent background in electricity and magnetism and mechanics.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Understand the scientific basis for controlled fusion by both magnetic confinement and inertial confinement approaches, as well as the technological requirements for practical electric power generation by the controlled fusion process.
- Be able determine the energy release of any nuclear reaction or reaction chain using the mass-energy relationship, and be able to solve well-posed engineering problems in plasma physics as applied to controlled fusion using Maxwell's equations and the equations of motion of charged particles in electric and magnetic fields.
- Be able to solve well-posed engineering problems in energy generation by controlled fusion having to do with the properties of materials in the presence of neutron irradiation and other relevant processes.
- Understand the fundamental role played by energy in our society and in the developing world, the potential role fusion can play, and the reasons that it is potentially more attractive than fission-based electric power generation.
- Be able to determine the state-of-the-art of different aspects of fusion reactor design by independent study using books, journals, conference proceedings, reports on the web and personal communication with experts.

Schedule of Classes (https://classes.cornell.edu/)

ECE 5870 - Energy Seminar I (1 Credit)
Crosslisted with CHEME 5870, MAE 5459, BEE 5459
Energy Seminars will explore energy-related topics of emerging, contemporary and historical interest. An abbreviated list of subjects explored in the seminars includes: global energy resources, energy generation technologies (present and future), energy storage options, environmental impacts and climate change mitigation, energy policy, and energy delivery economics and systems. Seminar speakers will be distinguished practicing engineers and executives from industry and government as well as faculty members from several departments at Cornell, and other academic institutions. Students from any department in Engineering or the Physical Sciences should find these talks informative.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5880 - Energy Seminar II (1 Credit)
Crosslisted with CHEME 5880, MAE 5469, BEE 5469
Energy Seminars will continue to explore energy-related topics of emerging, contemporary and historical interest. An abbreviated list of subjects explored in the seminars includes: global energy resources, energy generation technologies (present and future), energy storage options, environmental impacts and climate change mitigation, energy policy, and energy delivery economics and systems. Seminar speakers will be distinguished practicing engineers and executives from industry and government as well as faculty members from several departments at Cornell, and other academic institutions.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 5960 - Advanced Topics in Electrical and Computer Engineering (3-4 Credits)
Seminar, special interest, or temporary course.TermTopicInstructorFallMicro and Nano RoboticsE. HelblingSpringNetwork Dynamic and GamesF. Parise
Last Four Terms Offered: Spring 2026, Fall 2023, Spring 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5970 - Special Topics in Electrical and Computer Engineering (1-4 Credits)
Seminar, special interest, or temporary course.TermTopicInstructorSpringMolding Light FlowF. Monticone
Last Four Terms Offered: Fall 2024, Spring 2021, Fall 2020, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 5995 - Master of Engineering Design Project I (1-4 Credits)
Two-semester Design Project: must enroll in both semesters; students will receive a letter grade for each individual semester. For students enrolled in M.Eng. (Electrical and Computer Engineering) degree program. Uses real engineering situations to present fundamentals of engineering design. Each professor is assigned a section for the fall and spring. Students who do not complete the Design Project in the spring receive a grade only for the work completed up to the point of the required submission date, which is the last day of Finals Week. Students must then enroll for the summer with the ECE M.Eng. director to complete the work remaining for the design project.
Enrollment Information: Enrollment limited to: ECE MEng students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 5996 - Master of Engineering Design Project II (1-4 Credits)
Two-semester Design Project: must enroll in both semesters; students will receive a letter grade for each individual semester. For students enrolled in M.Eng. (Electrical and Computer Engineering) degree program. Uses real engineering situations to present fundamentals of engineering design. Each professor is assigned a section for the fall and spring. Students who do not complete the Design Project in the spring receive a grade only for the work completed up to the point of the required submission date, which is the last day of Finals Week. Students must then enroll for the summer with the ECE M.Eng. director to complete the work remaining for the design project.
Enrollment Information: Enrollment limited to: ECE MEng students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 5997 - Independent Study (1-4 Credits)
Independent study supervised by a faculty member in Electrical and Computer Engineering. A final report or exam is required. Students must make individual arrangements with a faculty sponsor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 5998 - Directed Research (1-4 Credits)
Research directed by a faculty member in Electrical and Computer Engineering. A final report or exam is required. Students must make individual arrangements with a faculty sponsor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 5999 - MEng Technical Internship (1-2 Credits)
This course offers M.Eng. students the opportunity to receive credit for ECE relevant work occurring as part of a summer (or semester) internship. Normally taken in the semester following the internship, students in the course will be required to write a detailed report describing the ECE related technical work performed during internship.
Enrollment Information: Enrollment limited to: ECE MEng students.
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 6210 - Theory of Linear Systems (3 Credits)
State-space and multi-input-multi-output linear systems in discrete and continuous time. The state transition matrix, the matrix exponential, and the Cayley-Hamilton theorem. Controllability, observability, stability, realization theory. At the level of Linear Systems by Kailath.
Prerequisites: MAE 3260 or ECE 3250, or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2023, Spring 2022
Learning Outcomes:

- Students will have an ability to develop state space models of dynamic linear systems in continuous time and discrete time based on physics models, input/output models, or rudimentary input/output experimental data.
- An ability to determine whether a system is controllable or observable.
- An ability to design stable state observers using pole placement.
- An ability to design stable full-state feedback controllers and observer-based controllers using pole placement.
- An ability to analyze system stability using pole locations and using the Lyapunov equation.

Schedule of Classes (https://classes.cornell.edu/)

ECE 6230 - Stochastic Systems: Estimation and Control (3 Credits)
The problem of sequential decision making in the face of uncertainty is ubiquitous. Examples include: dynamic portfolio trading, operation of power grids with variable renewable generation, air traffic control, livestock and fishery management, supply chain optimization, internet ad display, data center scheduling, and many more. In this course, we will explore the problem of optimal sequential decision making under uncertainty over multiple stages - stochastic optimal control. We will discuss different approaches to modeling, estimation, and control of discrete time stochastic dynamical systems (with both finite and infinite state spaces) over finite horizons. Solution techniques based on dynamic programming will play a central role in our analysis. Topics include: Fully and Partially Observed Markov Decision Processes, Linear Quadratic Gaussian control, Bayesian Filtering, and Approximate Dynamic Programming. Applications to various domains will be discussed throughout the semester.
Prerequisites: ECE 3100.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 6240 - Power System Economics and Electricity Markets (3 Credits)
Crosslisted with SYSEN 6230
This graduate-level course covers the fundamentals of power systems economics and electricity markets, emphasizing the application of microeconomics and optimization tools. The course introduces basic microeconomic concepts in the context of retail and wholesale electricity markets: consumer preference, consumer choice, production costs and profit maximization, individual and market demand and supply functions, competitive markets and equilibria, welfare optimization, market power, monopoly and price discrimination, regulated monopoly and utility pricing. The course covers electricity market design: energy markets, reserve markets, ancillary service markets, capacity markets, ancillary service markets, scarcity pricing, capacity markets, financial transmission rights, inter-regional transaction markets, and virtual transaction markets. Advanced topics on distributed energy resources and energy aggregation are discussed and assigned as part of class projects.
Prerequisites: MATH 2940, ECE 3100 or equivalent.
Last Four Terms Offered: Spring 2024, Fall 2021, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 6310 - Quantum Optics for Photonics and Optoelectronics (3 Credits)
This is a graduate level course on quantum optics. Topics covered include density matrices, semi-classical light matter interactions, Rabi oscillations, electromagnetically induced transparency and interference effects, dressed states, quantization of fields in cavity and free space, properties of photons, field commutation relations, number states, coherent states, quadrature and amplitude-phase squeezed states, vacuum fluctuations, matter-photon interactions, stimulated and spontaneous emission processes, classical/quantum descriptions of photon detection, coherent homodyne and heterodyne detection, coherence functions, cavity quantum optics and microcavity effects in spontaneous emission, cavity quantum optics in strong coupling and weak coupling limits, generation of quantum states of light, phase sensitive and phase insensitive optical amplifiers, parametric amplifiers, fundamental performance limits of optical amplifiers, photon statistics and characteristic functions, laser oscillators, numberand phase characteristics of laser light, parametric oscillators and squeezing, quantum opto-mechanics, opto-mechanical cooling and squeezing, noise penalty in simultaneous detection of two non-commuting field quadratures, bit error rates in optical communication systems, classical and quantum information and information carrying capacity of quantum states of light, quantum communications.
Prerequisites: ECE 3030 or AEP 3560 or equivalent, ECE 4060 or AEP 3620 or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2021, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 6320 - Applied Magnetism (4 Credits)
Fundamentals of magnetism, magnetic materials, and their applications. Topics include: sources of magnetism, types of magnetism, theory of electronic magnetism, magnetic anisotropy energies, domain theory, magnetic resonance, magnetostriction and magnetoelasticity, spin torques, thin-film phenomena, spin caloritronics, and permanent magnets. Current device and industry applications relevant to each topic will be discussed.
Prerequisites: ECE 3030, or AEP 3550 and AEP 3560.
Last Four Terms Offered: Fall 2024, Fall 2022
Learning Outcomes:

- Develop an ability to understand magnetic phenomena and predict magnetic behavior based on the competing anisotropy energies involved.
- Develop an ability to design magnetic and spintronic devices to meet the desired needs of industry and research.
- Develop an ability to interpret magnetic behavior based on knowledge of material properties and magnetic anisotropy energies.

Schedule of Classes (https://classes.cornell.edu/)

ECE 6540 - Advanced Analog VLSI Circuit Design (4 Credits)
Advanced analog integrated circuit and system design. Topics include integrated continuous-time filter design, translinear circuits and systems, dynamic analog techniques, integrated discrete-time filter design, and Nyquist-rate data converter design.
Prerequisites: ECE 4530.
Last Four Terms Offered: Spring 2024, Spring 2021, Spring 2019, Spring 2017
Schedule of Classes (https://classes.cornell.edu/)

ECE 6550 - Advanced High-Speed and RF Integrated Circuits (2 Credits)
Principles of analog integrated circuit design in the Giga-Hertz frequency range. This course covers the fundamental understanding of high-frequency circuit building blocks such as low noise amplifiers, mixers, oscillators, phase locked loops, frequency synthesizers, clock and data recoveries, and power amplifiers. Additionally, because some of the traditional microwave building blocks such as transmission lines and distributed circuit elements are essential parts of today's high speed integrated circuits, the course briefly covers them. Throughout the course, a systematic review of advanced wireless and wireline applications is covered. The course emphasizes physical understanding and intuitive design methods as well as qualitative techniques and computer simulations. The course has collaborative class projects, based on real-world problems.
Prerequisites: ECE 4530.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 6560 - Advanced Power Electronics (4 Credits)
Advanced topics in analysis and design of power electronics. Topics covered include advanced topologies for power conversion, including soft-switching, quasi-resonant, resonant, switched-capacitor and hybrid-switched-capacitor converters, advanced steady-state analysis methods, including state plane analysis and fundamental frequency analysis, zero-current and zero-voltage switching techniques, coupled magnetics, planar magnetics, matching networks, advanced dynamic modeling and control methods. Applications emphasized include high-power-density high-efficiency converters for emerging applications such as electric vehicles, data centers, robotics and wireless power transfer. Students should have knowledge of power electronics at the level of ECE 4560/5560 but no course is a prerequisite.
Enrollment Information: Enrollment limited to: Engineering students only.
Last Four Terms Offered: Spring 2026
Learning Outcomes:

- Demonstrate an understanding of accurate steady state analysis techniques and loss modeling for power converters
- Demonstrate an understanding of different topological and control approaches to increase power density and efficiency of power converters
- Ability to design compact and efficient high-frequency power converters
- Ability to design controllers for high-frequency power converters.

Schedule of Classes (https://classes.cornell.edu/)

ECE 6630 - Information Theory for Data Transmission, Security and Machine Learning (3 Credits)
This is a graduate-level introduction to mathematics of information theory. We will cover both classical and modern topics, starting from f-divergences, information measures and relations between them. With these tools we will study the fundamental limits of data transmission over noisy channels. Wiretap channels, where information-theoretic security versus a malicious eavesdropped must be ensured, will also be covered. Passive and adversarial models will be considered. Finally, we will explore connections between information theory and machine learning, examining how they can cross-fertilize each other.
Prerequisites: ECE 4110 or equivalent.
Last Four Terms Offered: Fall 2025, Fall 2023, Spring 2020, Fall 2014
Schedule of Classes (https://classes.cornell.edu/)

ECE 6640 - Statistical Inference and Decision (3 Credits)
Graduate level introduction to fundamentals of detection and statistical decision theory. Specific topics include simple and composite hypothesis testing, sequential detection and decision theory, nonparametric and robust detection, and change detection. Basic elements of game theory and its connections with statistical decision theory will be covered if time permits. Emphasis will be placed on discrete-time models and results.
Prerequisites: ECE 3100 and ECE 4110, or permission of instructor.
Last Four Terms Offered: Fall 2023, Fall 2022, Spring 2018, Fall 2015
Schedule of Classes (https://classes.cornell.edu/)

ECE 6660 - Control and Optimization of Information Networks (3 Credits)
Introduction to current research directions in networking featuring the Internet. Assumes basic knowledge of signals and systems as well as random processes. Necessary tools from optimization, dynamical systems, and related economic theory are introduced. Research topics may include layering, routing, medium access control, flow control, and peer-to-peer networks. Students are expected to hand in homework assignments, discuss one set of papers in class, and participate in a course project.
Prerequisites: ECE 4110 and ECE 4450.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 6680 - Bio-inspired Coordination of Multi-Agent Systems (4 Credits)
Autonomous multi-agent systems are becoming an integral part of our daily lives with thousands of robots and drones operating in places from warehouses to entertainment lightshows. With robot costs dropping to mainstream consumer levels, the current technological wave is driven by industry, researchers, and ambitious hobbyists, and spans applications in autonomous vehicles, construction, agriculture, and more. With this eminent technological revolution, it is critical that we look beyond robots working efficiently in parallel, and towards actual swarm intelligence for superior system ability and robustness beyond the sum of its parts. As a proof of concept, natural swarms exhibit efficient, error tolerant, and adaptive properties far beyond the individual scope. Beyond serving as an introduction to research, reading and review of scientific papers, this course also offers insights into both biology and the systems they have inspired.
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 6690 - Computer Analysis of Biomed Images (3 Credits)
Crosslisted with BME 5780
Powerful imaging modalities with attending computer image processing methods are evolving for the evaluation of health and the detection of disease. This course focuses on the quantitative analysis of such images and Computer Aided Diagnosis (CAD), i.e., the automatic identification and classification of abnormalities by the computer.
Prerequisites: ECE 5470 or equivalent.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 6695 - Principles of Magnetic Resonance Imaging (3 Credits)
Crosslisted with BME 6180, VETCS 6180
After a brief overview of all major medical modalities: x-ray, CT, MRI, SPECT/PET, and US, this course will focus on the formulations of spatial encoding and image contrasts as exemplified in MRI. The inverse problem between detected signal and image source will be discussed for biomedical applications. The concepts of image resolution, image contrast, SNR, and scan time will be illustrated quantitatively from an engineering point of view.
Prerequisites: functional knowledge and skills of linear algebra, calculus based physics, and knowledge of Fourier transformation.
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ECE 6745 - Complex Digital ASIC Design (4 Credits)
Principles and practices involved in the design, implementation, testing, and evaluation of complex standard-cell ASIC chips using automated state-of-the-art CAD tools. Topics include hardware description languages; CMOS logic, state, and interconnect fundamentals; chip design methodologies; automated cell-based design; CAD algorithms; details of accurately modeling ASIC delay, energy, and area; robustness issues; testing, verification, and debugging; power distribution and clocking; packaging and I/O. Includes a six-week open ended project where small groups of students design, implement, test, and evaluate an interesting technique in computer architecture using functional-, microarchitectural-, registertransfer-, and layout-level modeling.
Prerequisites: ECE 4750 or CS 4420 or ECE 5740.
Enrollment Information: Enrollment limited to Ithaca campus students.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 6750 - Advanced Computer Architecture (3 Credits)
Crosslisted with CS 5420
This course discusses advanced topics in computer architecture beyond the material that is covered in undergraduate courses such as ECE 4750/CS 4420. In particular, the course places special focus on multicore and multiprocessor architectures (coherence, consistency, synchronization, interconnects, OS support, etc.), as well as advanced architecture techniques (simultaneous multithreading, speculative loads and stores, neural branch predictors, hardware resource management, memory scheduling, etc.) Students work on parallel programming assignments that emphasize hardware-aware performance optimization.
Prerequisites: ECE 4750 or ECE 5740.
Enrollment Information: Enrollment limited to Ithaca campus students.
Last Four Terms Offered: Spring 2026, Fall 2024, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 6760 - Memory Technologies and Memory-Centric Computing (3 Credits)
The first half of this course will cover semiconductor memory technologies including SRAM, DRAM/eDRAM, and embedded non-volatile memories (RRAM, ferroelectric RAM, etc.). The lectures will encompass bitcell designs, array architecture, peripheral circuits, scaling trend, and target applications. The second half of this course will teach memory-centric computing, including SRAM/eDRAM/eNVM-based compute-in-memory designs and DRAM-based processing-in-memory designs, which have been demonstrated in both academia and industry in recent years.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2026, Spring 2025
Learning Outcomes:

- Students will identify different memory technologies and corresponding applications.
- Students will demontstrate how to design memory bitcells and arrays, with an understanding on the trade-off of density, power, noise margin, reliability, etc.
- Students will demonstrate SRAM-based compute-in-memory and DRAM-based processing-in-memory designs, which emerged as energy-efficient solutions for AI hardware.

Schedule of Classes (https://classes.cornell.edu/)

ECE 6770 - Resilient Computer Systems (4 Credits)
This course discusses principles and practices of designing secure and reliable computing systems, especially in the context of mobile System-on-Chips (SoCs). The course first introduces key concepts in reliability and security such as sources of faults and their manifestation, information redundancy, fault-tolerant hardware and software approaches, security properties, and cryptography. Then, the course uses modern SoCs for smartphones as a platform to discuss practical issues and techniques.
Prerequisites: ECE 4750.
Last Four Terms Offered: Fall 2019, Fall 2018, Fall 2017, Fall 2016
Schedule of Classes (https://classes.cornell.edu/)

ECE 6775 - High-Level Digital Design Automation (3 Credits)
The course starts with an introduction to modern electronic system design automation flow, before delving into high-level synthesis (HLS) design methodologies and tools for enabling digital system design above the register transfer level. Specific topics include C-based HLS design methods, hardware specialization, scheduling, pipelining, resource sharing, reconfigurable computing, and hardware/software co-design. This course also discusses the applications of a number of important optimization techniques, such as graph algorithms, dynamic programming, local search, and linear programming. In addition, commercial C-to- FPGA tools will be provided to the students to implement real-life image/video processing and machine learning applications on programmable system-on- chips that tightly integrate a dual-core processor and FPGAs.
Prerequisites: ECE 2300.
Enrollment Information: Enrollment limited to Ithaca campus students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 6780 - Multivariable Control Theory (3-4 Credits)
Crosslisted with MAE 6780
Introduction to multivariable feedback control theory in both time and frequency domain. Topics include model-based control, performance limitations, Linear Quadratic and H-infinity optimal control, control synthesis vis convex optimization, and model predictive control. Additional topics at the discretion of the instructor.
Prerequisites: MAE 4780 or MAE 5780, ECE 6210, plus a strong background in classical control, linear algebra, and state space models.
Last Four Terms Offered: Spring 2026, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to learn how to model dynamical systems for multivariable control by case studies.
- Students will be able to know state-space representation, transfer function matrix and transition matrix approaches.
- Students will be able to understand optimal control theory via case studies in linear quadratic regulator (LQR) and implicit model following (IMF).
- Students will be able to learn robust control theory including H-infinity control design.
- Students will be able to know adaptive control approaches including gain scheduling and model-reference adaptive systems (MRAS).
- Students will be able to gain a further understanding of modern control approaches including model predictive control (MPC), mu-synthesis, sliding mode control and feedback linearization in an independent project.

Schedule of Classes (https://classes.cornell.edu/)

ECE 6790 - Neuromorphic Computing Algorithm and Hardware Design (3 Credits)
Industry and academia have shown large interest in low-power hardware designs for neuromorphic computing (e.g. IBM TrueNorth, Intel Loihi) and deep learning algorithms for a wide range of image, speech, and biomedical applications. In this course, we will learn the underlying theory, basic algorithms, and efficient circuit/architecture design of neuromorphic computing.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- Gain an understanding on neuromorphic computing and neural networks.
- Learn how to design energy-efficient hardware accelerators for neuromorphic computing and neural networks.
- Learn how to properly optimize the performance/power/area of neuromorphic hardware designs.

Schedule of Classes (https://classes.cornell.edu/)

ECE 6950 - Graduate Topics in Electrical and Computer Engineering (3 Credits)
Special topics in Electrical and Computer Engineering for ECE graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ECE 6960 - Special Topics in Electrical and Computer Engineering (3 Credits)
Seminar, special interest, or temporary course.TermTopicInstructorSpringInterplay between Economics and SystemsA. Tang
Last Four Terms Offered: Spring 2026, Fall 2025, Spring 2025, Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 6970 - Graduate Topics in ECE (1-4 Credits)
Seminar, special interest, or temporary course.
Last Four Terms Offered: Fall 2024, Spring 2021, Fall 2020, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ECE 6980 - Graduate Topics in Electrical and Computer Engineering (3 Credits)
Seminar, special interest, or temporary course.
Last Four Terms Offered: Spring 2026, Spring 2023, Spring 2021, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

ECE 6990 - Special Topics in Electrical and Computer Engineering (1 Credit)
Seminar, special interest, or temporary course.TermTopicInstructorFallSucceeding in the Graduate EnvironmentA. El-Ghazaly
Last Four Terms Offered: Fall 2022, Fall 2021, Fall 2020, Fall 2016
Schedule of Classes (https://classes.cornell.edu/)

ECE 7210 - Network Systems and Games (3 Credits)
Network systems pervade our society in both social and technological contexts. On the one hand, social networks play a central role in the transmission of information and viruses with fundamental consequences for product marketing, technology adoption, voting decisions, spread of false news and epidemiology. On the other hand, network topology fundamentally affects the performance and resilience properties of large-scale multi-agent systems, such as the electric power grid, the internet of things, traffic or robotic sensor networks.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

ECE 7230 - Bayesian Estimation and Stochastic Optimization (4 Credits)
Covers essential topics in high dimensional statistical inference, stochastic optimization, Bayesian statistical signal processing and Markov Chain Monte-Carlo stochastic simulation. The course is four inter-related parts. Part 1 covers the basics of probabilistic models, Markov chain Monte-Carlo simulation and regression with sparsity constraints. Part 2 covers Bayesian filtering including the Kalman filter, Hidden Markov Model filter and sequential Markov chain Monte-Carlo methods such as the particle filter. Part 3 covers maximum likelihood estimation and numerical methods such as the Expectation Maximization algorithm. Part 4 covers stochastic gradient algorithms and stochastic optimization. The course focuses on the deep fundamental ideas that underpin signal processing, data science and machine learning. The discussion sections will focus on more advanced aspects in statistical inference.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2025, Fall 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will learn state of the art methods in Bayesian state estimation, parameter estimation and applications.

Schedule of Classes (https://classes.cornell.edu/)

ECE 7235 - Sustainable Urban and Energy Delivery Systems (3 Credits)
The course focuses on how to transition from legacy energy delivery infrastructures dependent on fossil fuel to a sustainable decarbonized grid that harnesses distributed renewable energy resources and responsive demand from buildings, electrified transportation systems, and industrial loads. The content includes models and abstractions for the architecture of the cyber-physical energy system, its economics, and future evolution, and numerical optimization and learning methods in support of the infrastructure's safety critical operations in the legacy system and in the future architecture. At the MSc level the students will focus on learning how to use tools and data while at the graduate level the students will be asked to also solve problems, formulate novel solutions, interpret results. Similarly, to differentiate the MSc from PhD level and course outcomes, the final project will require the MSc students to pick one out of a set of predefined problems while the PhD students will have to define an original problem and solution.
Prerequisites: coursework in ML, data science, law and policy or ethics, calculus and algebra, algorithms, and python programming. Recommended prerequisite: coursework in theory and optimization.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2025, Fall 2024, Spring 2023
Learning Outcomes:

- Students will be able to identify technical and operational models for energy delivery systems and appreciate why energy consumption in urban environments is bound to continue to be the most significant source of emissions under the status quo.
- Students will learn about and analyze emerging technological solutions in wide area sensing and IoT networks, machine learning and decision models that support the coordination the distributed renewable resources on the supply side with the flexible demand of electricity in urban environments.
- Students will identify security challenges that are unique of cyber-physical infrastructures and need to be addressed to advance to rip the benefits of digital technology in the field.
- Through assignments and projects, the students will gain hands-on experience in demonstrating on how to apply novel data models, network technology and software tools that encompass the various topics covered in the class.

Schedule of Classes (https://classes.cornell.edu/)

ECE 7260 - Graph-based Data Science for Networked Systems (3 Credits)
Complex networks are often the source of high-dimensional data. The goal of this course is to introduce structural and computational models for data that are indexed by the irregular support of a graph. The graph represents the network that couples the dynamics of many agents, or it can be a more abstract Bayesian graphical model that explains how observations are conditionally dependent. The interest in these models spans many fields.
Last Four Terms Offered: Spring 2026, Spring 2025
Learning Outcomes:

- Students will learn to analyze graph data as networks and understand their structural features.
- Students will learn models of network dynamics that occur in science and engineering that utilize the algebra of networks.
- Students will learn techniques to analyze data that result from network dynamics in Graph Signal Processing.

Schedule of Classes (https://classes.cornell.edu/)

ECE 7290 - Distributed Optimization for Machine Learning and AI (3 Credits)
This is a graduate-level course about theory, algorithms and applications of distributed optimization and machine learning. The course covers the basics of distributed optimization and learning algorithms and their performance analyses when they are used to solve large-scale distributed problems arising in AI, machine learning, signal processing, communication networks, and power systems.
Last Four Terms Offered: Fall 2025
Learning Outcomes:

- Be able to formulate optimization problems arising from machine learning, signal processing, and wireless communication tasks.
- Be able to implement numerically stable and scalable algorithms to solve practical optimization problems in large-scale learning and computing.
- Be able to quantify convergence rates and resource efficiency of optimization algorithms in terms of iteration, computation and communication counts.
- Be able to design, modify, and deploy optimization algorithms tailored to the structure and constraints of real-world learning and wireless computing systems. (For PhD students)

Schedule of Classes (https://classes.cornell.edu/)

ECE 7300 - Advanced Electrodynamics of Complex Media (3 Credits)
Graduate-level course on advanced topics in applied electrodynamics, metamaterials, and nanophotonics. The flow of electromagnetic waves can be controlled and molded with engineered (meta)materials and wave-guiding structures, for applications ranging from radio frequencies to visible light, and from large antenna/radar systems to nanoscale optics. Topics include the optical/electromagnetic properties of materials; conservation laws and theorems; causality and Kramers-Kronig relations; wave propagation in complex continuous media (anisotropic, dissipative, dispersive, chiral, nonlocal, nonreciprocal, hyperbolic, etc.) and periodic structures; coupled-mode theory in space and time; mode degeneracies and singularities; geometric phase and topology in wave physics. The course also introduces several topics at the forefront of applied research in this field, including nonreciprocal devices, super-resolution imaging, non-Hermitian physics, topological and time-varying photonics.
Prerequisites: ECE 3030 or AEP 3560.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- Demonstrate a fundamental understanding of the electromagnetic and optical properties of complex materials and metamaterials, as well as of the limitations and constraints stemming from causality, linearity, reciprocity, and passivity.
- Be able to model, calculate, and analyze the propagation properties of electromagnetic waves in complex media, such as anisotropic, hyperbolic, and chiral materials, magnetized plasmas and ferrites, and periodic structures.
- Be able to compare different approaches and choose the best design strategy to engineer the flow of electromagnetic waves, including for field confinement and enhancement, polarization rotation, energy transfer between coupled localized/guided modes, and unidirectional/nonreciprocal propagation.

Schedule of Classes (https://classes.cornell.edu/)

ECE 7620 - Fundamentals of Data Compression (3 Credits)
Fundamental limits and practical algorithms for data compression. Entropy and other information measures. Variable and fixed-length lossless and lossy source codes. Universal compression. Single-source and network configurations. Applications to text, multimedia compression, and machine learning. This course is intended for Ph.D. students. M.Eng. students should enroll in ECE 5620.
Enrollment Information: Enrollment limited to: MS/PhD students. Recommended prerequisites: ECE 4110 or equivalent.
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Demonstrate use of information measures including entropy, mutual information, relatively entropy, and their properties.
- Compute theoretical limits to compression for both lossless and lossy problems.
- Analyze the performance of lossless and lossy compression schemes, including comparing their performance against the theoretical limits.
- Design lossless and lossy compression algorithms for provided datasets that approach the theoretical limits.

Schedule of Classes (https://classes.cornell.edu/)

ECE 7910 - Thesis Research (1-15 Credits)
For students enrolled in master's or doctoral program. Each professor is assigned a section number. To register, see roster for appropriate six-digit course ID numbers.
Last Four Terms Offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ECE 7920 - Thesis Research (1-15 Credits)
For students enrolled in master's or doctoral program. Each professor is assigned a section number. To register, see roster for appropriate six-digit course ID numbers.
Last Four Terms Offered: Spring 2026, Spring 2025, Spring 2024, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ECE 7930 - Succeeding in the Graduate Environment (1 Credit)
This course will assist new graduate students in their transition to Cornell, by introducing them to on-campus resources and equipping them with the skills needed to succeed in research, academia, and their future careers. The course will address specific issues pertaining to diversity and minority resources. Guest panelists throughout the semester will include graduate students, administrators, and faculty across engineering and computer science.
Last Four Terms Offered: Fall 2023
Learning Outcomes:

- Identify resources available to graduate students on campus to meet whatever needs they have for personal, academic or professional development.
- Identify the key professional skills needed to evaluate their own present level of proficiency in each of these professional skills.
- Develop their professional skills.
- Create a plan for their own personal development, including: seeking mentorship in areas of desired growth and continually critique their individual progress.
- Understand the career paths available to graduate students after completion of the PhD.
- Differentiate between the various pathways towards those careers and develop a personalized plan by taking advantage of campus programs and resources.
- Establish a strong sense of community immediately upon entering into the PhD program.
- Identify potential community programs to get involved with as a medium for "giving back."

Schedule of Classes (https://classes.cornell.edu/)

ECE 7950 - Advanced Topics (1-4 Credits)
Schedule of Classes (https://classes.cornell.edu/)