So you want to be an electrical and computer engineering major…

Congratulations! You've chosen wisely. As an electrical and computer engineering major, you will acquire an incredibly broad skillset, learning to build circuits and systems, design computer hardware and software, manipulate data and information, invent new devices and materials, and utilize optics and photonics, all in service of the grand challenges facing the world in the coming century. Our curriculum encourages students to apply their knowledge in so many ways, including biomedical engineering, machine learning and artificial intelligence, high-performance and quantum computing, robotics and cyber-physical systems, information security, energy and the environment, and countless more. We're constantly amazed at the breadth of innovative paths our students take when they graduate. We know we'll be amazed at what you do too!

Over your six semesters in our department, you'll generally need to take 13 courses to earn your degree – four out of five required ECE courses, three technical electives in your chosen area of concentration, one elective outside your concentration to provide breadth, your thesis (which counts as two courses), an upper level math course, an engineering science course, and one more upper-level 'Departmental' course of your choice. That gives you an excellent ECE education, yet leaves half your schedule free to explore all that Princeton has to offer. Here's a brief look at what's in store – you can get all the nitty gritty details in our handbook.

Foundational Requirements (typically Sophomore Year)

ECE 201: Information Signals. Signals that carry information play a central role in technology and engineering — signals ranging from sound and images to sensors, radar, communication, MRI, ultrasound, touch-screens, GPS, and robotic control. You'll learn the mathematical tools to analyze, manipulate, dissect, and preserve information signals, and you'll apply these tools to design projects including a "Shazam" music identification system.

ECE 203: Electronic Circuit Design, Analysis and Implementation. This is your first introduction to how circuits work. You'll learn how to analyze circuits and, more importantly, to design and implement circuits. You'll get your first taste of biomedical engineering as you build a brain-machine interface that can display your current state of relaxation.

One of:

ECE 206: Contemporary Logic Design. This is your first introduction to digital logic that underpins modern computing. You'll learn to piece this logic together to design computer systems, and will build a fully-functioning computer using programmable logic.

ECE 308: Electronic and Photonic Devices. This course teaches you how semiconductor devices work, including transistors, lasers and solar cells. You'll also learn how to do micro- and nano-fabrication, and will go into the cleanroom to fabricate your own photodetectors, integrated circuits, and solar cells. (typically sophomore year.)

Junior Year

ECE 302: Robotic and Autonomous Systems Lab. The amazing carlab! You'll spend the first half of the semester getting to know and love your car, and learning how to build a complex system. Your car will use a digital camera to drive autonomously at a constant speed. In the second half of the class, you use the car as a platform to do anything you want – drift parallel parking, play soccer, catch a ball, map out the room – you pick the sensors and the platforms and do something incredible!

Senior Year

Thesis! (ECE 497/498). All electrical and computer engineering students do a two semester thesis as the culmination of their Princeton education. This is widely described as one of the most rewarding experiences at Princeton, and provides a chance to work closely with faculty to create something entirely new.

We have two flavors of thesis. Many students choose to work with a faculty member doing research in their area of expertise. This gives you a chance to learn and contribute to the cutting edge of an enormous variety of fields. Past theses have included researching a non-invasive glucose monitor, a trace gas sensing system, large area electronics, quantum computing, exoscale computing, privacy and security, big data and MOOCs, and machine learning.

We also have student-driven projects, where students come up with an idea that they want to implement. Students work under the mentorship of a faculty member, often outside of their area of expertise. Past student driven projects have included a drone-based avalanche rescue system, a multi-drone 3D cinematography system, a hybrid robot capable of switching between wheeled and legged operation, an origami folding robot, and a drone capable of flying and submerging underwater. Students often work in pairs or teams, often collaborating with students from other departments.

General SEAS Requirements

Upper Level Math. Students take one upper level math course of their choosing. Most ECE students take either differential equations (MAE 305) or probability (ORF309), but you can take any math course at the 300 level or above.

Engineering Science. Students take one course in a non-ECE SEAS discipline that is not a math course. This can be in any SEAS department, and often fills a cross-disciplinary interest. Most students fill this with COS 217 or COS 226, but there are countless options – a full list of common courses is in the handbook

Areas of Concentration

Beyond our required courses, you'll take three courses in one area of concentration, and one breadth course outside your concentration. Concentrations cover core areas within ECE and major applications, and are often interdisciplinary – one of your three concentration courses can be outside of ECE. We have ten areas of concentration:

Computer Systems. Unlock the secrets of how computing works at all levels of abstraction, from transistors to gates to bits to computer architecture to programs to algorithms. In this concentration, you will gain the knowledge to analyze and build complete computing systems which is at the heart of and the main driver of the great advances built on top of computing. Faster and more efficient computing systems have and will continue to drive great advances in our society from better entertainment systems to better rocket design (fluid flow modeling) to unlocking the mysteries of the human genome.

Circuits and Systems. Circuit-design is the business of using the physics of devices, connected into networks to create functions of high value to us. Modern circuits represent some of the most complex man-made systems, and they deliver functions of some of the highest importance to society. The concentration in Circuits and Systems will prepare you to push the frontier, with an emphasis on the biggest challenges faced in industry and academic research today.

Data and Information. How can HD video be compressed and sent over an LTE network to your phone? How are medical images acquired and analyzed to diagnose diseases? And how does Netflix learn about your taste on movies? These are some of the questions that underlie the concentration in data and information. Learn the principles and underlying theories exemplified by image and video processing, machine learning, data transmission and compression, information theory and networking.

Electronic Devices and Materials. New materials and devices lie at the heart of modern technology. Learn how semiconductor materials and devices work, and how to fabricate devices and characterize materials. Apply your learning to explore large area electronics, novel sensor networks, solar cells, and medical diagnostic devices.

Optics and Photonics. Light provides a powerful tool for imaging, sensing and communication. Learn how to generate and detect light and how lasers work, and apply your learning to biomedical imaging, photonic communications, and environmental sensing.

Quantum Information and Applied Physics. What kind of computers could you build if you could completely harness the bizarre laws of quantum mechanics? What kind of sensors become possible? Ones that are fundamentally different and seemingly impossible compared with what we have today, going well-beyond fundamental classical limits! Learn how they work and apply your learning to build real quantum systems!

Biomedical Engineering. ECE provides an incredible toolbox for understanding and manipulating biological systems. Learn to build and understand machine-brain interfaces, implantable electronics, biomedical imaging systems, and non-invasive optical probes, and to use data science to understand the brain and biological signals.

Security and Privacy. The security and privacy concentration aims to embed trust and resilience in our computing and communication infrastructure, including emerging paradigms based on Internet of Things, cyber-physical systems, social networks, connected cars and mobile, medical and wearable devices. The concentration includes the design of secure and resilient protocols that thwart sophisticated attackers, as well as approaches to protect the privacy of user data and communications.

Robotics and Cyber-physical systems. Electronic systems of the future will not only be aware of their surroundings, but capable of high-level planning and responses based on complex societal needs. Robotics and cyber-physical systems bring together sensors and actuators, computational subsystems, algorithms for inference and control, mathematical foundations for guaranteeing behaviors, and full system design and deployment. The concentration in Robotics and Cyber-physical Systems will prepare you in these aspects, looking forward to intelligent systems of the future.

Energy and the Environment. ECE provides a powerful toolbox for addressing global issues with energy and the environment. Learn how alternate energy sources work, how to design low-power electronics, how to manage and optimize a smart grid, and how to develop new environmental monitoring technology.

Slingshot Fund

What would you do if money were not an issue? Do you have a great idea that you would love to try out? A product you want to develop? A company you might want to launch? An internship you wish to pursue?

The Department of Electrical and Computer Engineering is pleased to announce the Stephen C. Johnson Slingshot Fund for Innovation, a prize to help launch your dreams and make them a reality. We will award between one and five grants a year, totaling up to $50,000, so funding for your idea could be substantial. This is not just another call for senior thesis or independent work funding, though that is one possibility.

This is a call to think bold and dream big, available to all electrical and computer engineering students. We want to enable you to do great things, and proposals will be judged based on creativity, boldness, and feasibility.

ECE Undergraduate Concentrations: the Details
All courses must be 300-level or higher.
For all concentrations, at least two courses must be ECE (or ECE cross-listed) courses.
Updated 11/12/21

Circuits and Systems
Required:
ECE 304 Electronic Circuits: Devices to ICs (S)
Two courses from:
- ECE 341 Solid State Devices (F)
- COS/ECE375 Computer Architecture and Organization (F)
- ECE 368 Intro to Wireless Communication Systems (S)
- ECE 382 Probabilistic Systems and Information Processing (S)
- ECE 462 Design of VLSI (F)
- ECE 464 Embedded Computing (S '22)
- ECE 472 Architecture for Secure Computers/Smartphones (S '22)
- ECE 475 Computer Architecture (S '22)
- ECE 481 Power Electronics (F)
- ECE 482 Digital Signal Processing

* ECE461 Design with Nanotechnologies, no longer offered, but past students may use it for this concentration

Data and Information
ORF 309* Probability and Stochastic Systems (F & S) is required. Then two or three courses from the list.*
- ECE 346 Intelligent Robotic Systems (S) NEW COURSE
- ECE 364** Machine Learning for Predictive Data Analysis (F)
- ECE 368 Intro to Wireless Communication Systems (S)
- ECE 381 Networks: Friends, Money and Bytes (not offered 21/22)
- ECE 382 Probabilistic Systems and Information Processing (S)
- ECE/COS 432 Information Security (F, S)
- ECE434/COS434 **Machine Learning Theory (F) Added to concentration
- ECE 482 Digital Signal Processing
- ECE 486 Transmission and Compression of Information
- ECE 435** Machine Learning and Pattern Recognition (F)
- COS 302/ECE305** Mathematics for Numerical Computing & ML (F)
- COS 324**Introduction to Machine Learning (F, S)
- COS 402 **Artificial Intelligence
- COS 424** Fundamentals of Machine Learning (S)
- COS 429 Computer Vision (F)
- ORF 350 Analysis of Big Data (S)
- ORF 363 Computing and Optimization for the Physical And Social Sciences (also COS 323) (S)

*ORF 309 can fulfill either the 300-level math requirement, or serve as one of the 3 Data and Information courses, but not both.
-If ORF 309 is taken to fulfill the 300-level math requirement, take 2 ECE courses from this list, plus any other course on this list.
- If ORF 309 is taken as one of the 3 D&I courses (implying another 300-level math course) take any 2 ECE courses from this list.
**Only one Machine Learning course may be applied to this concentration

Security and Privacy
Required:
COS/ECE 432 Information Security (F, S)
Two courses from:
- COS/ECE 375 Computer Architecture and Organization (F)
- ECE 364** Machine Learning for Predictive Data Analysis (F)
- ECE 435** Machine Learning and Pattern Recognition (F)
- ECE 464 Embedded Computing (S '22)
- ECE 472 Architecture for Secure Computers/Smartphones (S '22)
- COS 324**Introduction to Machine Learning (F, S)
- COS 402**Artificial Intelligence
- COS 424** Fundamentals of Machine Learning (S)
- COS 433 Cryptography (S)
- COS 461 Computer Networks (F)

** Only one Machine Learning course may be applied towards this concentration

Electronic Devices and Materials
Required:
ECE 341 Solid State Devices (F) (Pre-req is ELE 308**)
Two courses from:
- ECE 304* Electronic Circuits: Devices to ICs (S)
- ECE 308** Electronic and Photonic Devices (F)
- ECE 342 Principles of Quantum Engineering (S)
- ECE 431 Solar Energy Conversion (not offered 21-22)
- ECE 441 Solid-State Physics I (F)
- ECE 449 Micro-Nanofabrication and Thin-Film Processing (S)
- ECE 481* Power Electronics (F)
- ECE 557 Solar Cells (not offered '21'-22)
- MAE 324 Structure and Properties of Materials (F)
- MAE 424 Energy Storage Systems
- MSE 301 Materials Science and Engineering (S)
- MSE 302 Laboratory Techniques in Materials Science (F)
- MSE 505 Characterization of Materials (S)

* Only one circuits (304 or 481) course may be applied towards this concentration
**ECE308 does not count if taken as part of the Foundation Requirement

Computer Systems

Required:

COS/ECE 375 Computer Architecture and Organization (F)

Two courses from:

- ECE 368 Intro to Wireless Communication Systems (S)
- ECE 462 Design of VLSI (F)
- ECE 464 Embedded Computing (S'22)
- ECE 472 Architecture for Secure Computers/Smartphones (S '22)
- ECE 475 Computer Architecture (S'22)
- COS 318 Operating Systems (F)
- COS 320 Compiling Techniques (S)
- COS 461 Computer Networks (F)

Biomedical Engineering

Three courses from:

- ECE 304 Electronic Circuits: Devices to ICs (S)
- ECE 452 Biomedical Imaging (S)
- ECE 480 fMRI Decoding: Reading Minds (S '23)
- COS 429 Computer Vision (F)
- COS 455 Genomics & Computational Molecular Biology (F)
- MAE 344 Biomechanics and Biomaterials (S)
- NEU 427 Systems Neuroscience (F)
- NEU 437 Computational Neuroscience (S)

Robotics and Cyber-physical Systems

Three courses from:

- ECE 345 Intro to Robotics (F)
- ECE 346 Intelligent Robotic Systems (S) NEW
- ECE 304 Electronic Circuits: Devices to ICs (S)
- COS/ECE 375 Computer Architecture and Organization (F)
- ECE 364** Machine Learning for Predictive Data Analysis (F)
- ECE 435** Machine Learning and Pattern Recognition (F)
- ECE 464 Embedded Computing (S '22)
- ECE 481 Power Electronics (F)
- COS 324**Introduction to Machine Learning (F, S)
- COS 402** Artificial Intelligence
- COS 429 Computer Vision (F)
- MAE 433 Automatic Control Systems (F)

** Only one Machine Learning course may be used for this concentration

Optics and Photonics

Required:

ECE 351 Foundations of Modern Optics (F)

Two courses from:

- ECE 342 Principles of Quantum Engineering (S)
- ECE 452 Biomedical Imaging (S)
- ECE 453 Optical & Quantum Electronics (F)
- ECE 455 Optical and Photonics Systems for Environmental Sensing (S) Added to concentration
- ECE 458 Photonics and Light Wave Communications (F)
- ECE 456 Quantum Optics (S)
- MAE 521 Optics and Lasers (F)

Quantum Information and Applied Physics

ECE342** Principles of Quantum Engineering (S)

Two courses from:

- ECE 396 Introduction to Quantum Computing (F)
- ECE 441 Solid-State Physics I (F)
- ECE 453 Optical & Quantum Electronics (F)
- ECE 456 Quantum Optics (S)
- ECE 457 Experimental Methods in Quantum Computing (S) NEW
- ECE 568 Implementations of Quantum Information (F)

** PHY208 and 305 can be taken in lieu of ELE342, but are counted as one course for the concentration requirement

Energy and the Environment

Three courses from:

- ECE 341 Solid State Devices (F)
- ECE 431 Solar Energy Conversion (not offered '21-'22)
- ECE 455 Optical and Photonics Systems for Environmental Sensing (S) Added to concentration
- ECE 481 Power Electronics (F)
- ECE 557 Solar Cells: Physics, Materials, and Technology (not offered '21-'22)
- MAE 424 Energy Storage Systems