# Department of Electrical and Computer Engineering

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http://www.ece.cmu.edu/

The field of electrical and computer engineering encompasses a remarkably diverse and fertile set of technological areas, including analog and digital electronics, computer architecture, computer-aided design and manufacturing of VLSI/ULSI circuits, intelligent robotic systems, computer-based control systems, telecommunications and computer networking, wireless communication systems, signal and information processing and multimedia systems, solid state physics and devices, microelectromechanical systems (MEMS), electromagnetic and electromechanical systems, data storage systems, embedded systems, distributed computing, mobile computing, real-time software, digital signal processing, and optical data processing. The extraordinary advances in the field during the last fifty years have impacted nearly every aspect of human activity. These advances have resulted not only in advanced computer systems but also in consumer products such as "smart" cars, programmable dishwashers and other home appliances, cell phones and mobile computing systems, video games, home security systems, advanced medical systems for imaging, diagnosis, testing and monitoring. Systems and products such as these serve to enhance our quality of life and have also served as the basis for significant economic activity. In short, the field of electrical and computer engineering has become central to society as we know it.

The Department of Electrical and Computer Engineering at Carnegie Mellon is actively engaged in education and research at the forefront of these new technologies. Because of the diverse and broad nature of the field and the significant growth in knowledge in each of its sub areas, it is no longer possible for any single individual to know all aspects of electrical and computer engineering. Nevertheless, it is important that all electrical and computer engineers have a solid knowledge of the fundamentals with sufficient depth and breadth. Society is placing increasing demands on our graduates to try their skills in new contexts. It is also placing increasing value on engineers who can cross traditional boundaries between disciplines, and who can intelligently evaluate the broader consequences of their actions. Our curriculum is designed to produce world-class engineers who can meet these challenges.

## Educational Outcomes and Objectives

The B.S. in Electrical and Computer Engineering is a broad and highly flexible ABET-accredited degree program structured to provide students with the smallest set of constraints consistent with a rich and comprehensive view of the profession. Students are encouraged and stimulated to explore multiple areas of theory and application. The Faculty of Electrical and Computer Engineering have established the following objectives for the B. S. in Electrical and Computer Engineering curriculum:

### Educational Outcomes

(a) An ability to apply knowledge of mathematics, science, and engineering.

(b) An ability to design and conduct experiments, as well as to analyze and interpret data.

(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

(d) An ability to function on multi-disciplinary teams.

(e) An ability to identify, formulate, and solve engineering problems.

(f) An understanding of professional and ethical responsibility.

(g) An ability to communicate effectively.

(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

(i) A recognition of the need for, and an ability to engage in, life-long learning.

(j) A knowledge of contemporary issues.

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

### Educational Objectives

#### A. What they know

Our graduates will solve problems based on:

Fundamentals—knowledge of ECE fundamentals;

Breadth—understanding the breadth of areas in ECE;

Depth—substantive command of some specific area(s) of ECE.

#### B. How they think

Creatively—our graduates will develop creative solutions to problems in current and emerging applications.

Holistically—our graduates will define problems and formulate solutions from a systems perspective.

Strategically—our graduates will anticipate and plan for change and innovation, and engage in lifelong learning.

#### C. What they do

Initiate—our graduates will stand out for their resourcefulness, ingenuity, and ability to find innovative solutions to problems.

Collaborate—our graduates will work successfully in multidisciplinary teams.

Lead—our graduates will contribute to sustained improvement and development in their organizations, their profession, and society at large.

## Curriculum Overview

Minimum number of units required for degree: 379 units.

In addition to the Carnegie Institute of Technology general education and freshman year requirements (141 units), the B.S. in Electrical and Computer Engineering requires Effective Programming in C and Unix (9 units), Physics II (12 units), two math or science electives (18 units), a Probability and Statistics course (9 units), 109 units of Electrical and Computer Engineering coursework, and 2 math co-requisites (21 units). The remaining units needed to reach the 379 required to graduate are Free Electives (60 units).

The Electrical and Computer Engineering coursework is divided into the categories of Core, Breadth, Depth, Coverage, and Capstone Design. The Core consists of five courses (18-100 Introduction to Electrical and Computer Engineering, 18-220 Electronic Devices and Analog Circuits, 18-240 Structure and Design of Digital Systems, 18-243 Introduction to Computer Systems, and 18-290 Signal and Information Processing), and two math co-requisites. These courses provide the fundamental knowledge-base upon which all other electrical and computer engineering courses are built. 18-100 is generally taken during the freshman year, while the remaining courses in the Core are taken starting in the sophomore year. The four core courses are ideally completed by the end of the junior year. (The department strongly recommends that students not take more than two core courses in the same semester.) Although the core courses (and their co-requisites) may be taken in any order, students generally first take the course in their primary area of interest. This gives added flexibility to later course selection in related areas.

Students are also required to complete a seminar course during the fall semester of the sophomore year. This course, 18-200 Emerging Trends in ECE, introduces students to the many areas within ECE and helps them decide which areas are of primary interest to them.

To satisfy the ECE Breadth Requirement, at least one Breadth course must be completed from the lists of Breadth courses on the Web for two of the following five principal areas in ECE (24 units): Applied Physics: Solid State Physics, Electromagnetic Fields and Waves, Magnetics, Optics, etc.; Signals and Systems: Digital Signal Processing, Communication Systems, Control Systems, etc.; Circuits: Analog and Digital Circuits, Integrated Circuit Design, etc.; Computer Hardware: Logic Design, Computer Architecture, Networks, etc.; and Computer Software: Programming, Data Structures, Compilers, Operating Systems, etc.

For the ECE Depth Requirement, one course must be taken that has one of the ECE Breadth courses as a prerequisite. For Coverage any additional ECE course(s) can be taken or approved Computer Science course (see the ECE website for the list of approved Computer Science courses) totaling at least 12 units. Finally, all students are required to take a Capstone Design course. In the Capstone Design courses, numbered 18-5XX, students participate in a semester-long design projects with teams of other students. Students learn project management skills, make oral presentations, write reports, and discuss the broader social and ethical dimensions of ECE. Current Capstone Design courses are listed on the Web.

# B.S. Curriculum

Minimum number of units required for degree: 379

For detailed information and regulations of the curriculum along with the degree requirements and the most recent version of the ECE curriculum primer, please refer to the ECE World Wide Web Home Page: http://www.ece.cmu.edu/

## University Requirement

99-101/99-102/
99-103 Computing @ Carnegie Mellon 3 units

## CIT Requirements (see CIT section of the catalog for specifics):

CIT General Education 72 units

2 semesters of calculus 20 units

33-106 Physics for Engineering Students I 12 units
(33-106/107 is the recommended sequence for engineering students, although 33-111/112 or 33-131/132 would also meet the CIT Physics requirement)

1 other introductory engineering course 12 units
(generally taken during the freshman year)

## Specific ECE requirements:

1 Introduction to Electrical and Computer Engineering course, taken during the freshman year 12 units

18-100 Introduction to Electrical & Computer Engineering 12 units

1 ECE Seminar, taken during fall of the sophomore year 1 unit
18-200 Emerging Trends in ECE 1 unit

4 ECE core courses, three with math co-requisites 69 units
18-220 Electronic Devices and Analog Circuits 12 units
18-290 Signal and Information Processing 12 units
18-202 Math Foundations of Electrical Engineering 12 units
(co-requisite to 18-220 and 18-290)
18-240 Structure and Design of Digital Systems 12 units
21-127 Concepts of Mathematics (co-requisite to 18-240) 9 units
18-243 Introduction to Computer Systems 12 units

2 Breadth Courses from 2 of the 5 Breadth areas within ECE 24 units
1 Depth Course (with a Breadth course as a prerequisite) 12 units
1 Coverage Course (any additional ECE course or Approved CS course as listed on the ECE web site) 12 units
1 Capstone Design Course (a 18-5xx course ) 12 units

## Other ECE Requirements:

15-100 Introductory Programming 10 units
(taken during the Freshman year)
15-123 Effective Programming in C and Unix 9 units
(prerequisite to 15-213)
33-107 Physics for Engineering students II 12 units

2 Math/Science electives
18 units

The math/science requirement can be satisfied with any course from The Mellon College of Science or The Department of Statistics except for: 100-level courses in Mathematics or Statistics, and courses designed for non-science or engineering majors, such as 09-103, 09-104, 21-257, 33-124, 36-201, 36-202, 36-207 and 36-208. Although shown in the Fall of the Junior and Senior years, these courses may be taken at any time. Mathematics courses of particular interest to students in ECE are:

21-228 Discrete Mathematics
21-259 Calculus in Three Dimensions
21-260 Differential Equations

1 Probability and Statistics course
9 units

Either 36-217, Probability Theory and Random Processes or 36-220, Engineering Statistics and Quality Control or 36-225, Introduction to Probability and Statistics I. 36-217 (a prerequisite for 18-345, Introduction to Telecommunications Networks and 18-450, Digital Wireless Communications) is recommended for students interested in communications, control, networks, and signal processing. 36-220 is appropriate for students interested in quality control, manufacturing, and statistical methods. The two-course sequence 36-217 and 36-220 (or 36-225 and 36-226) will be of interest for Business Administration double majors.

## Free Electives
60 units

Additional courses to be used toward the required 379 units can be any graded course (i.e., not taken as Pass/Fail) taken from one of the academic units on campus (no Physical Education courses, StuCo or ROTC courses may be used toward Free Electives or any graduation requirements).

## Total: 379 units

The following table shows a possible roadmap through our broad and flexible curriculum:

| **Freshman Year** | | **Sophomore Year** | |
|---|---|---|---|
| **Fall** | **Spring** | **Fall** | **Spring** |
| Introduction to Electical & Computer Engineering (12) | Introductory Engineering Elective (12) | Emerging Trends in ECE (1) | ECE Core Course (12) |
| Introductory Programming (10) | Physics for Engineering Students I (12) | ECE Core Course (12) | Concepts of Mathematics/ Mathematical Foundations of EE (9/12) |
| Calculus (10) | Calculus (10) | Mathematical Foundations of EE/Concepts of Mathematics (12/9) | Effective Programming in C and Unix (9) |
| Writing/ Expression Course (9) | General Education Course (9) | Physics for Engineering Students II (12) | General Education Course (9) |
| Computing @ Carnegie Mellon (3) | | General Education Course (9) | Free Elective (9) |
| ***Total Units: 44*** | ***43*** | ***46/43*** | ***48/51*** |

| **Junior Year** | | **Senior Year** | |
|---|---|---|---|
| **Fall** | **Spring** | **Fall** | **Spring** |
| ECE Core Course (12) | ECE Core Course (12) | ECE Coverage Course I (12) | ECE Capstone Course (12) |
| ECE Breadth Course 1 (12) | ECE Breadth Course 2 (12) | ECE Depth Course (12) | General Education Course (9) |
| Probability and Statistics (9) | Math/Science Elective 1 (9) | Math/Science Elective (9) | Free Elective (9) |
| General Education Course (9) | General Education Course (9) | General Education Course (9) | Free Elective (9) |
| Free Elective (9) | Free Elective (9) | Free Elective (6/9) | Free Elective (9) |
| ***51*** | ***51*** | ***48/51*** | ***48*** |

## Notes on the Curriculum

### Policy on ECE Coverage Courses with Fewer than 12 Units

The basic curriculum requirements for Breadth, Depth, and Coverage are stated in terms of courses rather than units. The nominal total of 72 units for these categories is determined by assuming that each course is 12 units. In the event that courses with fewer than 12 units are used to satisfy some or all of these requirements, additional courses from the ECE coverage lists must be taken until the total units in ECE courses beyond the core meets or exceeds 72 units. Any ECE coverage course is acceptable, and any excess units may be counted as free elective credit.

### QPA Requirement and Overload Policy

An overload is defined as any schedule with more than 54 units in one semester. A student will only be permitted to overload by 12 units if he or she achieved a QPA of at least 3.5 out of 4.0 in the previous semester, or if his or her overall QPA is at least a 3.5.

### Pass/Fail policy

No course taken as Pass/Fail may be used in any way toward graduation (including Free Elective credit), unless the course is a required course and may **only** be taken pass/fail (such as 99-101 or 18-200).

### Other Graduation Requirements

CIT has the following requirement for graduation. "Students must complete the requirements for their specified degrees with a cumulative quality point average of 2.00 or higher for all courses taken after the freshman year. In addition, a student is expected to achieve a cumulative quality point average of 2.00 in a series of core departmental courses." In ECE, this means that the student must complete 18-100, ECE Core, Breadth, Depth, Coverage, and Design courses with a minimum QPA of 2.0 to graduate.

When more than one possibility exists for meeting a specific requirement (e.g., Breadth), the courses used for calculating the ECE QPA will be chosen so as to maximize the QPA. Similarly, when a course is retaken, the better grade will be used in the computation of the minimum QPA in the above courses.

## Other Opportunities in ECE

### ECE Cooperative Education Program

The ECE Co-Op is a unique 8-month contiguous extended internship experience in which ECE students with a minimum QPA of 3.0 may opt to participate in. Students typically engage in this option in the spring semester of their junior year, from January through August. A May through December option is also available. Students who engage in this program typically graduate in 4.5 academic years (but still eight semesters).

Eligible students interested in participating should apply to the ECE Undergraduate Office for the program at the close of their sophomore year. Students are required to submit a formal application consisting of a transcript, a resume, and a one-page statement of purpose including an academic plan. Students then work with the Career Center to find a Co-Op position. Once a Co-Op position is found, a Co-Op job description is required from the employer, to be approved by the ECE Undergraduate Office.

While on the Co-Op assignment, the students are participating in a recognized CIT educational program, retaining their full-time student status, akin to our students who study abroad in established exchange programs (such as EPFL) for one or two semesters.

Upon returning to Carnegie Mellon, the students are required to submit for approval the following two documents to the ECE Undergraduate Office: a three to five page technical report of the Co-Op work, and a one page assessment and evaluation of the Co-Op experience.

Students may obtain more detailed information through the department, the Career Center in the University Center, or online at http://www.ece.cmu.edu/undergrad/

### Integrated M.S./B.S. Degrees Program

The Integrated Master's/Bachelor's program (otherwise known as the IMB program) is an exciting opportunity for students who excel academically to achieve not just a Bachelor's degree in ECE, but also a Master's degree- through our Professional MS degree program- without needing to apply separately. This means no application fee, and no need to take the GRE (Graduate Record Exam) either.

If a student is at least a 2nd semester junior, has completed at least 270 units and has at least a 3.00 QPA, he or she is guaranteed admission into the Professional MS degree in ECE through the IMB program. To be officially admitted, the student must complete the IMB Program form.

Professional MS Degree Requirements:

Please see the ECE web site for the requirements for the Professional MS degree. For students in the ECE IMB program, all requirements for the Professional MS degree are in addition to the requirements for the BS in ECE. No requirements for the MS degree may be used in any way toward the BS degree, including minors, additional majors or dual degrees.

Residency requirements and financial impacts:

Once a student in the IMB program has completed all of the requirements for the BS degree, he or she may become a graduate (Masters) student. To do this, the student's undergraduate degree is certified, and that student officially graduates with the BS degree. Once a student's undergraduate degree has been certified, no more courses may then be applied toward the BS degree. This includes courses toward minors and additional majors, although students pursuing an undergraduate dual degree with another department may still continue to apply additional coursework toward that second degree.

If a student takes more than 8 semesters to complete both the BS and MS degrees, then he or she must be a graduate student for at least one semester before graduating.

To determine the most appropriate time for an undergraduate student to become a graduate student, he or she should consult with Enrollment Services to understand how becoming a graduate student will affect financial aid, and with his or her academic advisor to determine a course schedule. . When a student is a graduate student through the IMB program, the department is able to provide some financial assistance through Teaching Assistantships. Please see the ECE web site for further information regarding this financial assistance.

## Faculty

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