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 degree program structured to provide students with the smallest set of constraints consistent with a rich and comprehensive view of the profession. It is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. Students are encouraged and stimulated to explore multiple areas of theory and application. The Faculty of Electrical and Computer Engineering have adopted the following outcomes from ABET and have established the following objectives for the B.S. in Electrical and Computer Engineering curriculum:

Educational Outcomes

1. An ability to apply knowledge of mathematics, science and engineering.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. 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.
4. An ability to function in multi-disciplinary teams.
5. An ability to identify, formulate and solve engineering problems.
6. An understanding of professional and ethical responsibilities.
7. An ability to communicate effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
9. A recognition of the need for, and an ability to engage in life-long learning.
10. A knowledge of contemporary issues.
11. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

ECE Education Objectives

The ECE program objectives are shown below. They represent our vision for what our students will be doing in their engineering careers five years after they have graduated. The principal behaviors we seek to foster in our students are *expertise*, *innovation* and *leadership*.
Our graduates will be:

Experts

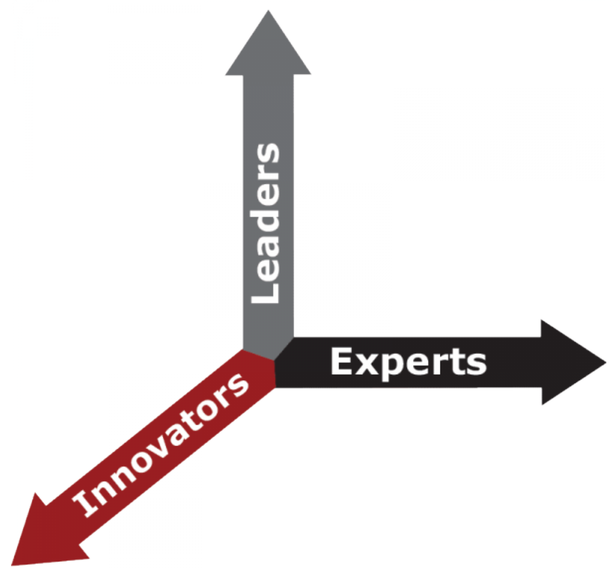
- They will solve problems by applying ECE fundamentals
- Their solutions will reflect depth of understanding in their sophistication.
- Their solutions will reflect breadth of understanding by drawing on multiple disciplines.

Innovators

- They will demonstrate creativity in their engineering practice.
- They will consider holistic systems-oriented approaches in their designs.
- They will think strategically in their planning and execution.

Leaders

- They will take initiative, and demonstrate resourcefulness.
- They will collaborate in multidisciplinary teams.
- They will be leaders in their organizations, their profession and in society.



Three dimensions of objectives for our graduates.

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 (143 units), the B.S. in Electrical and Computer Engineering requires 15-122 Principles of Imperative Computation (10 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 (57 units).

The Electrical and Computer Engineering coursework is divided into the categories of Core, Area Courses, 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, 18-213 Introduction to Computer Systems, and 18-290 Signals and Systems). There are also two math co-requisites (18-202 and 21-127) and Physics II that are required co-requisites for the core. 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 started in the sophomore year. The 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 ECE Sophomore Seminar, introduces students to the many areas within ECE and helps them decide which areas are of primary interest to them.

To satisfy the ECE Area Courses Requirement, at least two Area courses must be completed from one of the following five principal areas in ECE (24 units):

- *Device Sciences and Nanofabrication*: 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.

One additional course from a second area must be taken (12 units)

For Coverage any additional ECE course(s) can be taken or an 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 project 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 ECE Department website (http://www.ece.cmu.edu/programs-admissions/bachelors/academic-guide).

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 and course descriptions, please refer to the ECE Home Page: http://www.ece.cmu.edu/

University Requirement

99-101	Computing @ Carnegie Mellon	3
or 99-102	Computing @ Carnegie Mellon	

CIT Requirements (see CIT section of the catalog for specifics (http://coursecatalog.web.cmu.edu/carnegieinstituteoftechnology)):

CIT General Education	72
Two semesters of calculus	20
One other introductory engineering course (generally taken during the freshman year)	12

33-141	Physics I for Engineering Students **33-141/142 is the recommended course sequence, although 33-131/132 will also satisfy this requirement	12

Specific ECE requirements:

One Introduction to Electrical and Computer Engineering course (generally taken during the freshman year)		
18-100	Introduction to Electrical and Computer Engineering	12
One ECE Seminar, taken during the fall of the sophomore year		
18-200	ECE Sophomore Seminar	1
Four ECE core courses, three with math co-requisites		
18-220	Electronic Devices and Analog Circuits	12
33-142	Physics II for Engineering and Physics Students (co-requisite for 18-220)	12
18-290	Signals and Systems	12
18-202	Mathematical Foundations of Electrical Engineering (co-requisite for 18-220 and 18-290)	12
18-240	Structure and Design of Digital Systems	12
21-127	Concepts of Mathematics (co-requisite for 18-240)	10
18-213	Introduction to Computer Systems	12
Two Area Courses from 1 of the 5 Areas within ECE		24
One additional Area Course from a second Area		12
One Coverage Course (any additional ECE course or Approved CS course as listed on the ECE web site)		12
One Capstone Design Course (any 18-5xx course)		12

Other ECE Requirements:

15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
Two Math/Science electives		18
36-217	Probability Theory and Random Processes	9
or 36-225	Introduction to Probability Theory	
Free Electives		56

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 (but not limited to) 03-132, 09-103, 09-108, 21-240, 21-257, 33-115, 33-124, 36-201, 36-202, 36-207 or 36-208. Although shown in the Junior and year, these courses may be taken at any time. Mathematics courses of particular interest to students in ECE are:

21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9

[56 units]Free Electives

A Free Elective is defined as any graded course offered by any academic unit of the university (including research institutes such as the Robotics Institute (http://www.ri.cmu.edu) and the Software Engineering Institute (http://www.sei.cmu.edu)). A total of at least 56 units of Free Electives must be taken.

Up to 9 units of ROTC and Physical Education courses or other courses taken as Pass/Fail may also be used toward Free Electives.

Transfer of courses from other high-quality universities may be accepted through submission of the Transfer Credit Request form on the CIT web page (http://www.cit.cmu.edu/current_students/services/transfer_credit.html).

The large number of units without categorical constraints provides the student, in consultation with their Faculty Advisor or Mentor, with the flexibility to design a rich educational program.

Sample Curriculum

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

Freshman		Sophomore	
Fall	**Spring**	**Fall**	**Spring**
18-100 Introduction to Electrical and Computer Engineering	Introductory Engineering course	18-200 ECE Sophomore Seminar	18-2xx ECE Core course
15-112 Fundamentals of Programming and Computer Science	33-106 Physics I for Engineering Students	18-2xx ECE Core Course	21-127 Concepts of Mathematics or 18-202 Mathematicl Foundations of Electrical Engineering
21-120 Differential and Integral Calculus	21-122 Integration and Approximation	18-202 Mathematical Foundations of Electrical Engineering or 21-127 Concepts of Mathematics	15-122 Principles of Imperative Computation
76-101 Interpretation and Argument	General Education course	General Education course	36-217 Probability Theory and Random Processes
99-101 Computing @ Carnegie Mellon		33-142 Physics II for Engineering and Physics Students	General Education course
		39-210 Experiential Learning I	39-220 Experiential Learning II

Junior		Senior	
Fall	**Spring**	**Fall**	**Spring**
18-2xx ECE Core course	18-2xx ECE Core course	18-xxx ECE Coverage course	18-5xx ECE Capstone Design course
18-3xx/4xx ECE Area 1 course (first course in Area)	18-3xx/4xx ECE Area course (either 2nd course from Area 1 or the Area 2 course)	18-3xx/4xx ECE Area course (either 2nd course from Area 1 or the Area 2 course)	General Education course
General Education course	Math/Science Elective 2	General Education course	Free Elective
Math/Science elective 1	General Education course	Free Elective	Free Elective
Free Elective	Free Elective	Free Elective	Free Elective
39-310 Experiential Learning III			

Notes on the Curriculum

Policy on ECE Coverage Courses with Fewer than 12 Units

The basic curriculum requirements for Area courses, Coverage and Capstone Design are stated in terms of courses rather than units. The nominal total of 60 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 60 units. Any ECE coverage course is acceptable, and any excess units beyond the required 60 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 she or he achieved a QPA of at least 3.5 out of 4.0 in the previous semester for which he or she is registerin, or if his or her overall QPA is at least a 3.5.

Grade Policy for Math Courses

1. CIT states that all mathematics (21-xxx) courses required* for the engineering degree taken at Carnegie Mellon must have a minimum grade of C in order to be counted toward the graduation requirement for the BS engineering degree.

2. A minimum grade of C must be achieved in any required mathematics (21-xxx) course that is a prerequisite for the next higher level required mathematics (21-xxx) course.

3. In addition, ECE requires that 18-202 Mathematical Foundations of Electrical Engineering must be completed with a grade of C or better.

*Elective mathematics courses (like the math/science electives required for ECE) are not included in this policy

Pass/Fail policy

Up to 9 units of ROTC and Physical Education courses or other courses taken as Pass/Fail may be used toward Free Electives. ECE core courses may not be taken as pass/fail. ECE project-based courses (including capstone design courses) may not be taken pass/fail. No ECE requirements may be fulfilled using a pass/fail course (except for 99-10x and 18-200)

Other Graduation Requirements

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.0. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. Students are encouraged to confirm all graduation requirements with their academic advisor.

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 [this is the CIT QPA on the Academic Audit].

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 Introduction to Electrical and Computer Engineering, ECE Core, Area Courses, Coverage, and Capstone Design courses with a minimum QPA of 2.0 to graduate. When more than one possibility exists for meeting a specific requirement (e.g., Area Course), the courses used for calculating the ECE QPA will be chosen so as to maximize the QPA. Similarly, when an ECE course is retaken, the better grade will be used in the computation of the minimum QPA for the ECE QPA requirement to graduate.

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 contact their advisor in the ECE Undergraduate and Graduate Programs Office. 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 NCTU or 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/programs-admissions/bachelors/index.html

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). In order to be awarded the MS degree in the IMB program, the student must also earn their BS degree, either simultaneously with the MS degree or at least one semester prior to the awarding of the MS degree. If a course is eligible for the MS degree but must be used to complete the BS degree, the BS degree takes priority over the MS degree.

If a student is at least a 2nd semester junior, has completed at least 270 units and has at least an overall 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.

If a student does not meet the exact overall 3.00 QPA requirement, he or she is eligible to petition for his or her admission into the IMB program during his or her senior year. Students may obtain the petition forms through a meeting with their assigned academic advisor.

Professional MS Degree Requirements:

Please see the ECE web site for the requirements for the Professional MS degree (http://www.ece.cmu.edu/programs-admissions/masters/ms-requirements.html). 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 with the MS degree.

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

DAVID ANDERSEN, Adjunct Professor of Electrical and Computer Engineering.
JAMES ANTAKI, Professor of Biomedical Engineering, Courtesy Professor of Electrical and Computer Engineering; Associate Professor of Bioengineering and Surgery at the University of Pittsburgh – Ph.D., University of Pittsburgh; Carnegie Mellon, 2014–.
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