

# ELECTRICAL ENGINEERING (MS, PHD)

The Electrical and Computer Engineering (ECE) department offers Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in Electrical Engineering with two possible areas of concentration: Electronics, Photonics and Biophotonics or Information, Communication, Decision, and Energy Systems. In addition, Ph.D. students can take a track in Computer Engineering, either along with one of the areas of concentration or separately. The ECE faculty research spans these areas including projects on control and communications, radar, data fusion, signal and image processing, robotics, sustainable energy systems, semiconductor devices, nanotechnology, and computer engineering.

## M.S. in Electrical Engineering

The M.S. degree program satisfies several different needs. Many students enter the M.S. degree program to round out their educational objectives, prior to seeking employment in a specialized field of study within Electrical Engineering. In this case, the M.S. degree represents a terminal point in their formal studies. Other students plan to continue their studies at the Ph.D. level. In this case the M.S. degree represents a preparatory period designed to give the student the tools and background needed to carry out the more individualized and self-directed research involved in Ph.D. studies.

Either approach is designed to provide comprehensive knowledge of the theoretical and applied aspects of the student's chosen area of concentration. The graduate program is predicated on students having developed a strong technical background in basic Electrical and Computer Engineering through work in undergraduate courses. The objective of the graduate program is to enhance this background by providing more advanced course work, along with insight into state-of-the-art problems and new research areas.

The Master's degree may be earned under either of two plans as determined by the student and the advisory committee: Plan A, emphasizing research, and Plan B, emphasizing graduate course work.

### M.S. Plan A Requirements

Students must take a minimum of 30 credits in the program. Typically, this consists of 9-12 credits each semester.

Students complete at least 21 credits of graduate course work. Some students may need more than seven courses to complete Plan A of study. Final determination is made by the student and the student's advisory committee. Students in the Electronics, Photonics, and Biophotonics area may include no more than six credits of ECE 6099 Independent Study in Electrical Engineering; students in the Information, Communication, Decision, and Energy Systems area may include no more than three credits of ECE 6099 Independent Study in Electrical Engineering; at least nine credits of GRAD 5950 Master's Thesis Research; satisfactory completion of a Master's thesis, with oral presentation; one credit of ECE 6094 Seminar; have one conference proceedings (CP) (full) paper accepted by the time of graduation. A journal paper may be substituted for the CP.

### M.S. Plan B Requirements

Students must take a minimum of 30 credits in the program. Typically, this consists of 9-12 credits each semester. Requirements: At least 30 credits of graduate work, with no more than six credits of ECE 6099

Independent Study in Electrical Engineering and one credit of ECE 6094 Seminar for full-time on-campus students. Students must also pass a comprehensive M.S. examination, which is based on the core course work.

## M.S. Concentration Requirements

In addition to the general requirements listed above, both Plan A and Plan B students who choose to do an area of concentration must also meet the following requirements:

### Electronics, Photonics, and Biophotonics

**Required Courses:** At least one course from each of the three areas:

- Area 1 - Electromagnetics/Photonics
- Area 2 - Semiconductor/Optoelectronic Devices
- Area 3 - Applications

It is not necessary that the remaining courses taken be in the Electronics, Photonics, and Biophotonics area, although they generally tend to be.

### Information, Communication, Decision, and Energy Systems

Course	Title	Credits
<b>Required Courses</b>		
ECE 5101	Introduction to System Theory	3
ECE 6111	Applied Probability and Stochastic Processes	3
ECE 6122	Digital Signal Processing	3
ECE 6151	Communication Theory	3
ECE 6439	Estimation Theory and Comp Algorithms	3

It is not necessary that the remaining courses taken be in the Information, Communication, Decision, and Energy Systems, although generally they tend to be.

## Ph.D. in Electrical Engineering

### General Requirements

All students in the Ph.D. program must maintain a cumulative GPA of 3.0 or above; pass a two-part general examination near the end of the formal course work; and complete a dissertation which represents a significant contribution to the field.

In addition, students must meet the following minimum research publications requirements:

1. Two conference proceedings, full length papers accepted with first authorship (Journal Papers may be substituted for conference proceedings) by the time of the proposal presentation.
2. Three journal papers with first authorship by the time of the dissertation defense, two accepted and one submitted. With the approval of the advisory committee, up to two journal papers may be replaced by full proceedings papers with first authorship presented at leading international conferences with a documented acceptance rate of under 30% based on data from the previous year. In either scenario, at least one journal paper should have been accepted by the time of the defense.

Students must also meet a related area requirement, which can be satisfied by six credits of additional graduate work in any single technical area (such as Computer Science, Statistics, Physics, Mathematics, or another Engineering field).

The student's Plan of Study should be completed according to the following requirements and approved before the Ph.D. General Examination. The student's Advisory Committee has the final word on all Plan of Study matters. After the Plan of Study is approved, a Ph.D. Dissertation Prospectus should be submitted at least six months before the defense.

In addition to these general requirements, students who choose to do an area of concentration and/or the Computer Engineering track must satisfy the requirements specific to those specialties outlined below.

### Ph.D. in Electrical Engineering: Electronics, Photonics, and Biophotonics Concentration

**Requirements:** Minimum of 30 credits of content coursework beyond the baccalaureate (or its equivalent) or at least 15 credits of content related coursework beyond the master's degree or other advanced degree in the same or a closely-related field of study; two credits of ECE 6094 Seminar.

A student will select six (Ph.D.) courses for the written exams in consultation with their advisory committee. At least one course should be chosen from each area:

- Area 1 - Electromagnetics/Photonics
- Area 2 - Semiconductor/Optoelectronic Devices
- Area 3 - Applications

### Ph.D. in Electrical Engineering: Information, Communication, Decision, and Energy Systems Concentration

#### For Student Holders of M.S. Degree

Students must take at least 12 credits of appropriate graduate course work and six credits of related area graduate course work. Of these a maximum of three credits may be ECE 6099 Independent Study in Electrical Engineering. The related area can be satisfied by six credits of graduate work in any single technical area (such as Computer Science, Statistics, Physics, Mathematics, or another Engineering field).

ECE 5101 Introduction to System Theory, ECE 6111 Applied Probability and Stochastic Processes, and ECE 6122 Digital Signal Processing are introductory basic graduate courses and should not normally count toward the 12 required credits for the Ph.D. In special circumstances, a Systems subgroup Ph.D. student's M.S. background may be considered to have little in common with the Systems subgroup M.S., but nonetheless to be a significant contribution to the students Ph.D. research. In such cases the student's Advisory Committee may decide that some or all of these courses may be counted toward Ph.D. totals. Such cases are assumed to be unusual.

**Requirements:** ECE 6094 Seminar must be taken for credit at least twice. Attendance at this seminar is required every semester for full-time students. A minimum of 15 credits of GRAD 6950 Doctoral Dissertation Research.

The Ph.D. General Examination for Information, Communication, Decision, and Energy Systems students who are not in the Energy Systems subgroup consists of:

Course	Title	Credits
<b>Required Courses</b>		
ECE 5101	Introduction to System Theory	3
ECE 6111	Applied Probability and Stochastic Processes	3

ECE 6122	Digital Signal Processing	3
Select one of the following:		
ECE 6099	Independent Study in Electrical Engineering	3
ECE 6121	Information Theory	
ECE 6151	Communication Theory	
ECE 6437	Computational Methods for Optimization	
<b>Electives</b>		
Two additional courses in agreement with the Advisory Committee		6
<b>Total Credits</b>		<b>18</b>

The General Examination for students in the Energy Systems subgroup consist of seven exams: three or four of ECE 5101 Introduction to System Theory, ECE 6111 Applied Probability and Stochastic Processes, ECE 6122 Digital Signal Processing, and ECE 6439 Estimation Theory and Comp Algorithms; three or four appropriate courses in Energy Systems.

#### For Student Holders of B.S. Degree

Students must take at least 30 credits of appropriate graduate course work and six credits of related area graduate course work. Of these a maximum of three credits may be ECE 6099 Independent Study in Electrical Engineering. The related area can be satisfied by six credits of graduate work in any single technical area (such as Computer Science, Statistics, Physics, Mathematics, or another Engineering field).

**Requirements:** ECE 6094 Seminar must be taken for credit at least two times. Attendance at this seminar is required every semester for full-time students. A minimum of 15 credits of GRAD 6950 Doctoral Dissertation Research.

The Ph.D. General Examination consists of the same as in the Ph.D. requirements for students starting with an M.S. degree.

The Ph.D. General Examination for Information, Communication, Decision, and Energy Systems students who are not in the Energy Systems subgroup consists of:

Course	Title	Credits
<b>Required Courses</b>		
ECE 5101	Introduction to System Theory	3
ECE 6111	Applied Probability and Stochastic Processes	3
ECE 6122	Digital Signal Processing	3
ECE 6439	Estimation Theory and Comp Algorithms	3
Select one of the following:		
ECE 6099	Independent Study in Electrical Engineering	
ECE 6121	Information Theory	
ECE 6151	Communication Theory	
ECE 6437	Computational Methods for Optimization	
<b>Electives</b>		
Two additional courses in agreement with the Advisory Committee		6
<b>Total Credits</b>		<b>21</b>

The General Examination for students in the Energy Systems subgroup consist of seven exams: three or four of ECE 5101 Introduction to System Theory, ECE 6111 Applied Probability and Stochastic Processes,

ECE 6122 Digital Signal Processing, and ECE 6439 Estimation Theory and Comp Algorithms; three or four appropriate courses in Energy Systems.

## **Computer Engineering Track Ph.D. Requirements**

### **For Student Holders of M.S. Degree**

**Requirements:** A minimum of five ECE or CSE graduate courses (15 credits). Of these a maximum of three credits may be ECE 6099 Independent Study in Electrical Engineering. The seminar ECE 6094 Seminar has to be taken for credit at least twice. A minimum of 15 credits of GRAD 6950 Doctoral Dissertation Research.

The Ph.D. General Examination consists of four exams on Computer Architecture, VLSI Design, Systems, and Algorithms. After the Plan of Study is approved, a Ph.D. Dissertation Prospectus should be submitted and presented before the advisory committee.

### **For Student Holders of B.S. Degree**

**Requirements:** A minimum of 11 ECE or CSE graduate courses (33 credits). Of these a maximum of three credits may be ECE 6099 Independent Study in Electrical Engineering. The seminar ECE 6094 Seminar has to be taken for credit at least twice. A minimum of 15 credits of GRAD 6950 Doctoral Dissertation Research.

The Ph.D. General Exam consists of four exams on Computer Architecture, VLSI Design, Systems, and Algorithms. After the Plan of Study is approved, a Ph.D. Dissertation Prospectus should be submitted and presented before the advisory committee.