# **ELECTRICAL ENGINEERING, PH.D.**

### **PhD in Electrical Engineering**

The Department of Electrical and Computer Engineering offers a Doctor of Philosophy degree in Electrical Engineering. This is a research-based degree where students are required to propose, complete, and defend an approved dissertation on a research topic that contributes to the field.

The PhD program in Electrical Engineering provides students with the opportunity to work with leading, world-renowned faculty members in four focus research areas:

### • Devices and Materials

This research area is focused on fundamental and applied research on materials and devices. Active research includes magnetic materials for electromagnetic devices in electric machines; synthesis of nanomaterials for electronic and photonic nanodevices; oxide materials for MEMS piezoelectric and multiferroic sensors/actuators. A group of ECE faculty work on a broad spectrum of solid-state devices, including solar cells, sensors, and terahertz (THz) biomedical imaging.

#### · Electromechanical and Energy Systems

This research area focuses on the design, development, and control of electrical systems and combined electrical and mechanical systems. On the electrical system side, research activities include Electric Power and Energy Systems and Power Electronics with modern applications covering renewable energy systems, microgrids, vehicle grid integration, smart grid, energy internet, etc. Within the sub-discipline of power electronics, several faculty are involved in design and optimization of high-performance converters utilizing emerging wide-bandgap semiconductor technology including Silicon Carbide (SiC) and Gallium Nitride (GaN) devices. Management and mitigation of electromagnetic interference (EMI) in high-frequency SiC and GaN converter systems is also an active area of research within the department. On the integrated electrical and mechanical system side, research activities include Electric Machines, Energy Conversion, and Motion Control Systems with modern applications covering electric vehicles, wind energy conversion, smart homes and buildings, process automation, robotics, etc.

#### Embedded Systems

This research area is focused on computing systems in all aspects and applications. Active research by the UA ECE faculty includes robotics, intelligent sensors, computer vision, machine learning and deep learning, wearable sensors, security and privacy in computing systems, intelligent wireless communications and networks, big data, tele-healthcare, systems-on-chip, virtual reality, IoT devices, biosensors, implantable devices, and autonomous driving, flying, and underwater vehicles. The research area also covers embedded system hardware (microcontrollers and FPGAs), digital signal/ image processing, real-time systems, and biomedical applications of computing devices.

### Electromagnetics.

Electromagnetics involves solving Maxwell's four equations and is the underpinning of the electromagnetic device and system design. Maxwell's equations describe the law of electricity and magnetism. Electromagnetics applies the four equations to electromagnetic device performance analysis. Microwave communications, radio propagation in antennas, microwave millimeter engineering, remote sensing, and object imaging are based on electromagnetics' dynamic field.

### Admissions

In addition to the minimum Graduate School admission requirements, to be considered for regular admission an application must include:

- A Bachelor's degree in electrical or computer engineering or related field from an ABET-accredited program. Applications who are graduates of a non EAC/ABET-accredited program will be considered.
- 2. A short Statement of Purpose describing possible research/study interests
- 3. A Resume
- 4. Applicants who are not current University of Alabama students should submit three letters of recommendation

Students who do not meet these requirements, but who excel in other areas, may be considered for "Admission with Permission to Continue."

# Applicants Without an Electrical Engineering or Computer Engineering Bachelor's Degree

Applicants without an electrical engineering or computer engineering bachelor's degree may be admitted with Permission to Continue. Such students will be required to complete successfully three 400level electrical engineering courses, each in a different sequence area. Successful completion requires a "B" or better in the course. Slash-listed (400/500) courses taken to satisfy this policy cannot be counted toward the graduate degree. Equivalent undergraduate or graduate courses in related fields (for example, electromagnetics in physics, computer architecture in computer science, or control in mechanical engineering) may be counted as a course in the corresponding electrical engineering area upon approval by the Electrical and Computer Engineering Graduate Program Director.

See the Admission Criteria section of this catalog for more information.

### **Curricular Requirements**

	Code and Thie	Hours
1	Major Area of Concentration	
	A minimum of 24 hours of closely related coursework in the student's area of concentration, as defined by the advisory committee, with at least 15 of these hours at the 500-level or above. At least 9 hours should be at the 600 level. Courses at the 400-level will only be applied to this hour requirement if they were completed as part of the student's master's degree requirements.	24
f	Minor Area of Concentration	
	A minimum of 15 hours of courses in a minor in Electrical and Computer Engineering or other approved area, as defined by the advisory committee, all of which are to be at the 500-level or above	15
	Mathematics or Science	
	A minimum of 6 hours of Mathematics (MATH, STAT or GES) or Science (Physics, Chemistry, or Biology) courses at the 500-level or above	6
	Graduate Research Seminar	
	A minimum of 3 hours of seminar (ECE 695 Graduate Research Seminar). This can be part of the Major Area of Concentration or the Minor Area of Concentration.	3
С	Total Coursework Hours	48
	Dissertation Research	

A minimum of 18 hours of dissertation research (ECE 699 Dissertation Research) are required

#### **Total Hours**

Additional Requirements:

- A maximum of 24 credit hours earned for coursework taken to complete a master's degree can be applied to the doctoral coursework requirement.
- The Graduate Research Seminar can be considered as part of the student's Major Area of Concentration or Minor Area of Concentration with approval from the student's advisory committee. However, the minimum of 48 coursework hours must still be met.
- A student's curriculum and dissertation must be approved by the student's graduate advisory committee. All candidates must pass a written and oral qualifying examination, administered by the graduate advisory committee, at such a time as the candidate's adviser deems appropriate and in accordance with departmental policy. The oral portion of the qualifying examination is typically as the presentation of a dissertation proposal. Furthermore, all candidates must pass a final examination, which generally consists of a presentation and defense of the dissertation.
- A doctoral student must fulfill the residency requirements set forth by The University of Alabama Graduate School.

### **Transfer Credit**

Please see the Graduate School website.

### Committee

Every Ph.D. candidate is responsible for working with his/her advisor to select a committee of five or more members. The candidate's committee will consist of the advisor plus at least three members of the department's faculty plus at least one faculty member from outside the department. The committee will work with the advisor to approve the candidate's plan of study, to evaluate the candidate's dissertation and plan the dissertation defense, as well as to help the candidate with any problems that may arise in the course of obtaining the Ph.D. degree.

# **Doctoral Plan of Study Requirement**

Soon after admission to the Ph.D. program, you should work with your advisor and committee to complete the Outline of Doctoral Program for the Ph.D. Consult the graduate course schedule for help with choosing the coursework that will be listed in this 3-year plan of study. Courses listed in the plan of study may be modified during your course of study with the approval of your advisor. It is the student's responsibility to keep the graduate school informed of revisions to the Plan of Study, as this document is used to audit the student's courses prior to admission to candidacy and graduation.

### **Comprehensive Exams**

The Ph.D. qualifying examination is a formal process used to evaluate a student's capacity for successfully completing the Ph.D. program. Successful completion of the qualifying examination is required of all Ph.D. students prior to admission to candidacy. The qualifying examination consists of both an oral and a written component, which may be administered at different times. However, both portions of the qualifying exam must be completed at least nine months before graduation. It is also noted that the qualifying exam and the dissertation defense cannot occur within the same semester.

### Written Component

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The content, nature, and format of the written component of the qualifying examination is determined by the student's graduate advisory committee. This portion of the qualifying examination may be taken when the advisory committee determines that sufficient coursework has been completed, but no later than the semester immediately after all coursework has been completed. Prior to issuing the written component to the student, the chair of the graduate advisory committee will submit a written statement defining the content, duration, and nature of the exam to the Department Head, each member of the committee, and the student.

The written examination will be based upon graduate-level coursework in the student's major area of concentration. The examination provides a vehicle for the student to demonstrate the capability to apply independent thinking by bringing together material from a number of different courses.

There is no specific requirement for the content or format of the written portion of the qualifying examination. However, graduate advisory chairs often request that members of the graduate advisory committee contribute a suitable set of questions or a project, which collectively represent a comprehensive qualifying examination for the student. External graduate advisory committee members may also contribute questions if desired, at the discretion of the graduate advisory chair.

In this model, the questions or projects contributed by the members of the graduate advisory committee may be open-ended (requiring literature review, etc.) or they may be taken from graduate coursework. Regardless of approach, it is generally recommended that the scope of each committee member's questions be constrained such that the student can complete them in 1-2 weeks of concentrated effort.

The graduate advisory committee will decide whether the student passed or failed the written exam. The chair of the graduate advisory committee will inform the student and the Department Head in writing of this result within two weeks of the completion of the written exam. Students may take this written exam only twice. The graded exam will become part of the student's academic file. The written portion of the qualifying examination must be successfully completed prior to undertaking the oral portion of the qualifying exam.

### **Oral Component**

The oral component of the qualifying examination will include a formal presentation of the dissertation proposal to the graduate advisory committee. At least two weeks prior to this presentation, the student must submit a written draft of the proposal to the graduate advisory committee, who approves the formal proposal defense.

## **Admission to Candidacy Requirements**

When the student has presented a satisfactory proposal, the chair of the graduate advisory committee will inform the Department Head that the student passed both the written and oral portions of the Qualifying Exam and has been admitted to candidacy. The completed candidacy form with attached Plan of Study is submitted to the Graduate School well in advance of the final semester.

# **Continuous Enrollment Policy**

Please see the Graduate School website.

## **Dissertation Requirements**

The dissertation research and dissertation are the defining elements of the PhD degree. The dissertation must demonstrate independent, original scholarship within the field. The dissertation is a formal research document and must be prepared following the Graduate Schools guidelines. Your dissertation will be reviewed by your advisor and your dissertation committee. Your advisor will help in scheduling your Final Exam/Dissertation Defense. After a successful defense, you may still have final dissertation corrections and revisions required by the committee. Such conditions should be considered in scheduling the presentation/defense relative to the graduate school submission deadlines.

The article-style dissertation can be used as an alternate to the traditional dissertation format. This format is beneficial for publication of the dissertation research. Additional information concerning the article-style dissertation may be found at the site listed above.

### **Dissertation Defense**

The final step in the pursuit of the Ph.D. degree is a formal defense of the completed dissertation before the student's graduate advisory committee. The dissertation defense consists of two major components.

The first component is a technical presentation that summarizes the major findings of the dissertation. This presentation should include a survey of the available literature, a summary of the major technical achievements of the research described in the dissertation, and a synopsis of the contributions of the research to the broader engineering community. The technical presentation is followed by a question and answer session, during which audience members may ask the student specific questions about his or her dissertation research. This portion of the defense must be open to the public.

The second component of the dissertation defense is a closed question & answer session that is restricted to the defending student and the graduate advisory committee. This portion of the defense is not open to the public. The graduate advisory committee will typically ask a series of detailed questions about the student's dissertation research. After the committee has concluded asking questions, the student will be asked to leave the room so that the committee may deliberate and render a decision on whether the student has passed or failed the dissertation defense. After a decision has been reached, the student will be called back into the room and notified of this decision.

The dissertation defense must be announced publicly. The procedure for public announcement is as follows. No less than four weeks before the scheduled defense date, the student must complete a dissertation announcement document, which includes the following elements: the student's name, the student's email address, the advisor's name, the dissertation title, and abstract of no more than 300 words, and the scheduled date and time of the defense. A template of this announcement form is available from the ECE office staff.

When the dissertation announcement document is complete, it should be sent to the ECE office staff for distribution. This will generally be done at the same time that the room reservation for the defense is scheduled.

To ensure that this policy is enforced, ECE office staff will not schedule a room for a dissertation defense without first receiving the completed dissertation announcement document. After receiving this document, the ECE office staff will add the confirmed room location, and will then send this document to the department email distribution list. The document will also be posted to the ECE department website and sent to the office of the dean for further distribution within the College of Engineering.

### Time Limits for Degree Completion Requirements

Please see the Graduate School catalog page.

### **Student Progress Requirement**

Please see Satisfactory Academic Progress Website.

### Academic Misconduct Information

Please see the Graduate School catalog page.

# Withdrawals and Leave of Absence Information

Please see the Graduate School catalog page.

### **Academic Grievances Information**

Please see the Grievance Procedure catalog page.

### **Scholastic Requirements**

Please see the Graduate School catalog page.

## **Graduate School Deadlines Information**

Please see the Graduate School Website.

### **Application for Graduation Information**

Please see the Graduate School catalog page.