

ELECTRICAL ENGINEERING, PH.D.

Ph.D. 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 Ph.D. program in Electrical Engineering provides students with the opportunity to work with leading, world-renowned faculty members in four core 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; and 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 as well as 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 ECE faculty includes robotics, intelligent sensors, computer vision, machine learning, 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 ground, air, 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 foundation for electromagnetic device and system design. Maxwell's equations describe the laws 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 common subdisciplines.

Admissions

A. Regular Admission Requirements

For regular admission to the graduate program in the ECE Department, a prospective graduate student should have:

- 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.
- Grade point average of at least 3.0 on a 4.0 scale, 3.0 for the last 60 semester hours in a degree program, or 3.0 for a completed graduate program.
- Combined verbal and quantitative GRE requirement of 300 or greater.

There is no minimum score on the writing section of the GRE for admission to the Ph.D. Program.

GRE Verbal and Analytical Writing scores must be consistent an international applicant's English language score.

Non-native speakers are required to submit unofficial TOEFL, IELTS, DET, or PTE scores (official scores are submitted on admission) unless they meet at least one of the following criteria:

- At the time of initial enrollment, they will hold a degree from a U.S. institution or an institution in one of the English-speaking countries or regions in the link below;
- At the time of initial enrollment, they will have been enrolled in coursework for at least two years at a U.S. institution or an institution in one of the English-speaking countries or regions in the link below;
- They are a citizen or legal resident of one of the English-speaking countries or regions in the link at: <https://graduate.ua.edu/prospective-students/international-admissions/>.

The minimum score(s) to be considered for regular admission:

TOEFL: 79, IELTS: 6.5, DET: 110, PTE: 59.

Admission with Permission to Continue may be granted to applicants who do not meet these requirements, for example those who have degrees in related fields or a GPA below 3.0.

Please see the Graduate School website for more details.

B. Admission Requirements for 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 400-level 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.

C. Required Application Materials

In addition to the online application form, the following information is required as part of your application:

1. A short Statement of Purpose describing possible research/study interests
2. Resume
3. External applicants should submit three letters of recommendation
4. English proficiency test results (TOEFL, IELTS, DET, PTE)
5. GRE test scores
6. Transcripts for any institutions where 15 or more credit hours were completed

D. Application Deadlines

There are no formal deadlines for graduate applications. Once an application is complete, the internal review process typically takes 2-3 weeks. However, **international applicants** should consider the time required to obtain any necessary visa documents.

Curricular Requirements

Code and Title	Hours
Major Area of Concentration	
A minimum of 21 hours of closely related coursework in the student's area of concentration, as defined by the advisory committee, with at least 12 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.	21
Minor Area of Concentration	
A minimum of 9 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	9
Mathematics or Science	
A minimum of 3 hours of Mathematics (MATH, ST, or GES) or Science (Physics, Chemistry, or Biology) courses at the 500-level or above	3
Graduate Research Seminar	
ECE 695 Graduate Research Seminar (3 hours of seminar. This can be part of the Major Area of Concentration or the Minor Area of Concentration.)	3
Total Coursework Hours	36
Dissertation Research	
A minimum of 18 hours of dissertation research (ECE 699 Dissertation Research) are required	18
Total Hours	54

Additional Requirements:

- A maximum of 18 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 36 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.
- As part of their research, a student must have at least one journal manuscript accepted for publication.
- Until a Ph.D. student is admitted to candidacy for the doctoral degree, ECE 698 should be taken to reflect research hours. Credit hours awarded for ECE 698 do not count toward the Ph.D. degree and ECE 698 hours cannot be converted into ECE 699 hours.

Graduate Seminar

The ECE department holds a seminar series each regular academic term.

In addition to student presentations, outside speakers distinguished in some area of engineering are invited to make seminar presentations. Graduate students are expected to attend these seminars.

There is a one-hour course that students may take to obtain course credit for this seminar series each semester. Ph.D. students are required to complete 3 hours of seminar before graduation.

Grades and Academic Standing

Please see the Grades and Academic Standing catalog page.

Transfer Credit

The UA Graduate Catalog provides a comprehensive high-level description of graduate transfer credit policies, and they supersede any departmental policies. Hence, graduate course credit earned prior to enrollment at UA is evaluated according to the UA Graduate Catalog. This document is intended to summarize long-standing and tested policies that have been in place within the ECE department.

Procedure

1. Students desiring to receive transfer credit must complete the *Request for Transfer of Graduate Credit* form, available on the UA Graduate School website, and have an official transcript from the institution where the credit was received on file at UA.
2. The completed form should be submitted to the Graduate School, who will then send it, along with the student's transcript, to the student's advisor (via the departmental staff) for initial evaluation. The faculty advisor will evaluate each course for transfer credit and complete Part III of the request form. They will submit the completed form to the Graduate Program Director.
3. The Graduate Program Director will review the request and communicate with the student's advisor until approval can be granted. The ECE Department and the Graduate School must approve any transfer credit.

General Requirements and Limits

1. Per Graduate School policy, transfer credit will be awarded only for courses in which the student received a grade of B or better, and only for courses taken at an accredited university.
2. Students must have an overall GPA of at least 3.0/4.0 at the institution from which the credit will be transferred.
3. Specific courses may only be transferred if they were earned within six years of being admitted to the Ph.D. program.

4. Transfer credit will be awarded only for courses that the student's advisor deems appropriate for the chosen specialization of study. General requirements of what courses can be accepted within a specialization can be found on the departmental website.
5. The maximum number of credit hours that may be transferred may not exceed one-half of the coursework hours required for the degree (i.e. 18 hours). This excludes Research and Dissertation hours, and thus the number of transfer hours will typically be less than one-half of the total number of hours required for the degree.
6. Only credit hours earned for standard coursework may be transferred. Research hours, laboratory hours, and project hours are all ineligible for transfer.
7. For applicants holding an MS degree not earned during the previous six years, the student must demonstrate field-relevant employment to earn the maximum hours of transfer credit for that MS degree. Additional information is available in the Graduate School Catalog under the Transfer Credit heading.
8. Note that the graduate school has very strict deadlines regarding the transfer of credit.

Assignment of Credit

1. For each course requested to be transferred, when an equivalent or "near-equivalent" course is available at UA, transfer credit for that UA course number will be awarded, subject to the items in the General Requirements and Limits section above. In general, if transfer credit is deemed to be equivalent to a UA course, and transfer credit for that UA course number is given, the student is no longer eligible to take that course at UA.
2. It is quite common for students to enter UA with graduate credit from other institutions for courses that we do not offer. If these courses meet the conditions under the General Requirements and Limits section above, then credit for ECE 593 or ECE 693 will be awarded, as appropriate for the level of the course being transferred. This assignment process is consistent with UA Graduate School, College of Engineering, and UA Registrar policies.

Please see the Graduate School information on Transfer Credit.

Doctoral Plan of Study Requirements

Soon after admission to the Ph.D. program, students should work with their advisor and advisory 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 a student's course of study with the approval of the 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 graduation.**

Residence Requirements

In addition to completing a minimum of 50% of the graduate coursework at The University of Alabama (UA), all of the dissertation research hours (699) must be earned while attending UA. Note that 599 hours are not the same as 699 and these hours generally cannot be converted. Note also that once ECE 699 courses are started, students must continuously register for a minimum of 3 hours of ECE 699 each semester until graduating. There are a few exceptions for the final semester, depending on when the dissertation defense is completed. See the Graduate Catalog for additional information.

Comprehensive Qualifying Examination

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

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 advisory 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. 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 portion of the Qualifying Exam.

Candidacy and Continuous Registration

A student who has successfully completed the qualifying examinations and has had a dissertation research proposal approved will be admitted to *candidacy* for the doctoral degree. The completed candidacy form with attached Plan of Study is submitted to the Graduate School well in advance of the final semester. Students admitted to candidacy are expected to pursue completion of the dissertation without interruption by enrolling each semester following admission to candidacy for at least three hours of dissertation research (ECE 699).

Dissertation and Final Examination Requirements

The dissertation research and dissertation are the defining elements of the Ph.D. 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 School guidelines. The dissertation will be reviewed by the advisor and advisory committee. The advisor will help in scheduling the student's Final Exam/Dissertation Defense. After a successful defense, there may be additional 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.

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.

Graduate Advisory Committee

Every Ph.D. candidate is responsible for working with his/her advisor to select an advisory 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.

Time Limits for Degree Completion

All requirements for the Ph.D. degree must be completed during the nine years immediately prior the date that the degree is awarded.

Please see the Graduate School catalog page under the heading "Time Limits".

Student Progress Requirement

Please see the Satisfactory Academic Progress Website.

Academic Misconduct Information

Please see the Graduate School catalog page for information on Academic Misconduct.

Withdrawals and Leave of Absence Information

Please see the Graduate School catalog page for information on Withdrawals and Leave of Absence.

Academic Grievances Information

Please see the Grievance Procedure catalog page.

Application and Deadlines for Graduation

Please see the Graduate School catalog page for information on the Application for Graduation.

Unconditionally admitted full-time graduate students may seek and receive financial assistance in the form of a graduate assistantship.

Assistantships generally include a monthly stipend as well as all or a part of tuition and health insurance. Graduate assistantships are highly competitive and being admitted into the graduate program does not in any way guarantee an assistantship award.

Graduate Research Assistantships (GRAs) are awarded by individual professors with funded research. Applicants should communicate directly with a faculty member in the applicant's area of interest concerning the availability of GRA positions and a potential match.

The ECE Department offers Graduate Teaching Assistantships (GTAs) for students assisting faculty members with undergraduate courses and laboratories. GTA awards are determined by the ECE Department

Administration at the request of individual faculty members who submit GTA applications on behalf of their students. A university-wide requirement for all GTAs is that they should either have English as their native language or have successfully completed an English language proficiency course and passed an English language proficiency exam administered by UA's English Language Institute. The English language proficiency exam and course process typically require at least one semester. There is a limited number of GTA positions each semester.

The GRAs and GTAs must register for a minimum number of credit hours based upon their level of funding as described in the Graduate Catalog. GTAs/GRAs are also expected to perform a minimum number of work hours per week as part of their position. A full-time GTA/GRA is expected to work 20 hours per week; a half-time GTA/GRA is expected to work 10 hours per week. Accepting an assistantship implies an obligation on the part of the student. Students supported by an assistantship are expected to fulfill their roles as students, meeting all academic requirements, as well as carrying out teaching and/or research assignments. Students who do not maintain good academic standing, as defined in the UA Graduate School, are not eligible for assistantships. Assistantships may also be terminated by faculty advisors for unsatisfactory performance of the assigned research and/or teaching duties. The ECE Department is not obligated to provide funding for students terminated from their positions.

It should be noted that a loss in funding does not equal dismissal from a program, for students in good academic standing and who have not been found to have committed misconduct worthy of dismissal.

Domestic students may be eligible for student loans and other financial aid and should visit the UA Financial Aid Office website to learn more about these options.

Additional support is available in the form of fellowships, available from the University and other funding agencies. Applicants are encouraged to visit the Graduate School website to learn more about these opportunities, application requirements and deadlines. Some professional societies also offer assistance to new graduate students.

Qualified applicants are encouraged to apply for fellowships like the NSF Graduate Research Fellowship, the DoD SMART Fellowship, the Alabama Space Grant Consortium Fellowship, and UA's Graduate Council Fellowship. Note that most of these have early application deadlines and some require interaction with a nominating faculty member.

Additional information can be found on the Financial Assistance page of the Graduate Catalog.