

## Requirements for the Doctor of Philosophy in Electrical and Computer Engineering

### 1) Acceptance into the Ph.D. Program

- a) Academic records, letters of recommendation, GRE scores, and the statement of purpose are all taken into consideration.
- b) All applicants are required to take the Graduate Record Examination (GRE).
- c) All applicants for whom English is not the native language must take either the Test of English as a Foreign Language (TOEFL) with a minimum score of 88, or the International English Language Testing System (IELTS) with a minimum score of at least a 7.0. Applicants are exempt from this requirement if they have earned a degree from an institution or in a country where English is the primary (official) language.
- d) Any student pursuing a Master's degree at Vanderbilt who wishes to continue work at Vanderbilt toward the Ph.D. must apply for the Ph.D. program through the University Admissions Office. The student must notify his or her advisor and the Director of Graduate Studies (DGS) in writing and obtain approval before enrolling in course work beyond that required for the Master's degree. Normally, no coursework may be applied toward the fulfillment of the Ph.D. requirements until all requirements for the Master's degree are satisfied. Permission may be given to do so if progress toward the completion of the Master's degree is judged satisfactory by both the student's advisor and the DGS.

### 2) Student Advisor and Committee Selection

- a) If upon entering the Ph.D. program a student does not have an advisor the DGS shall assign one pro tempore. By the end of the first year in the Ph.D. program each candidate is expected to consult with relevant faculty members to discuss possible research topics. The final selection of an advisor is a decision made by the student, his or her proposed advisor, and the DGS.
- b) Each Ph.D. student must have a Ph.D. Committee. The Committee is to be composed of at least five members of the Graduate School faculty. At least 50% of the Committee members shall be ECE faculty, and at least one of the Graduate School Faculty Committee members shall have a primary appointment in a discipline other than ECE. The student's Ph.D. advisor shall serve as chair of the committee. The committee is recommended by the student and the student's advisor with considerations for research and directions of academic growth. The committee must be approved by the DGS and the Dean of the Graduate School.
- c) The student's Ph.D. committee is to be selected, and its membership is to be submitted, to the DGS office and the Graduate School before the student may take the Ph.D. qualifying examination (Section 9). The committee is responsible for evaluating the progress of the student.

### 3) Course Requirements

- a) A total of 72 hours is required for the Ph.D. Of these, at least 24 hours of formal didactic coursework or seminar work are required in ECE or other areas directly related to the student's research. The courses selected must be approved by the student's advisor. Independent study may not be applied toward the 24 coursework hours.
- b) The courses taken must include one gateway course in each of the three following areas of ECE: Materials, Devices, and Microelectronics; Signals and Analysis; and Systems, Control and Computing. Gateway courses must be approved by the advisor and the DGS through the Study Plan document. The gateway courses must be completed prior to taking the Preliminary exam (Section 8) which must be taken after completion of 18 hours and before the completion of 24 hours of course and research work.
- c) The 48 required hours beyond the 24 coursework hours may be entirely dissertation research hours or a combination of research, independent study, and course hours that are appropriate for the student's plan of study. Note: After the qualifying exam has been passed and the required 72 hours have been met Ph.D. research is registered each semester for 0 hours. Hours beyond 72 require the approval of the advisor and the DGS.
- d) Up to 24 graduate credit hours may be transferred from graduate schools in approved institutions. Any graduate transfer credit taken in ECE or a closely related area in approved programs may be counted towards the 24 hour ECE course requirement defined in Section 3.a. The student must obtain approval from his or her advisor and the DGS before submitting the request to the Graduate School.

### 4) Plan of Study

- a) It is the student's responsibility to submit a formal study plan to his/her advisor during the student's first semester in the Ph.D. program. The plan includes a milestones and deadlines document (Section 4.b) and a set of courses related to the student's research area. The courses must include three gateway courses as described in Section 3.b. It must be approved by both the advisor and the DGS. The plan may be updated by the student with the approval of the advisor and the DGS. The study plan document, with all its updates, will be kept in the permanent record of the student by the graduate student coordinator.
- b) The milestones and deadlines document lists by semester of study, the key steps in the study plan proposed by the student and approved by the advisor. The plan can be quite flexible with respect to the distribution of coursework and research hours but less so with respect to the timing of the preliminary exam (Section 8), the qualifying exam (Section 9), and the dissertation defense (section 10). A typical 5-year plan follows.

Semester 1: Three 3-hour courses including 1-3 gateway courses (See Section 3.b).

Semester 2: Three 3-hour courses including 1-3 gateway courses (See Section 3.b).

Semester 3: One 3-hour course, 6 hours non-candidate research, prelim exam.

Semester 4: One 3-hour course, 6 hours non-candidate research.

- Semester 5: 9 hours non-candidate research.
- Semester 6: 9 hours non-candidate research, qualifying exam.
- Semester 7: 9 hours Ph.D. research.
- Semester 8: 9 hours Ph.D. research.
- Semester 9: 0 hours Ph.D. research.
- Semester 10: 0 hours Ph.D. research, dissertation defense.

Specific plans may vary from this. One common variation is to intersperse research hours with course hours. As part of the formal study plan, the milestones and deadlines document will serve as a guide to the student's progress throughout his/her degree and as a baseline for evaluation by the faculty at the annual review of all graduate students (the grad hash). Of particular importance is that the student and the advisor be aware of the expected deadlines for course completion including the gateway courses, the preliminary examination, the qualifying examination, and the dissertation defense.

#### 5) Grade Requirements

a) Graduate grades are A, B, C, and F, with corresponding grade points 4, 3, 2, and 0. Plus "+" or minus "-" grades add or subtract one half (0.5) grade points. PhD level research (non-candidate and candidate) hours are typically S or U for satisfactory or unsatisfactory and carry no grade points.

b) The overall grade point average for formal coursework applied toward the Ph.D. must be 3.0/4.0 or better. A "C" in a course in the field of major interest or a "U" in research is cause for review of the student's status and academic progress by his or her committee. One "F" or two "C" grades in courses or two "U"s in research are cause for being dismissed from the program. Final decisions in such cases will be made by vote of the department's graduate faculty as a whole. To be eligible to take the preliminary exam, the student must earn a grade of B- or better in each of three gateway courses.

#### 6) Maximum Course Load

A normal full-time load for graduate study is 9-13 hours per semester (0-9 hours in the summer session). In exceptional cases, a student may register for more than 13 hours (9 hours summer) with the approval of his or her Ph.D. advisor and the DGS.

#### 7) Progress Requirements and Evaluation

- a) At the end of each spring semester, the Ph.D. student's academic progress shall be discussed with his or her Ph.D. advisor. The student will submit to the DGS a written report on his or her progress for the preceding year and plans for the next year. The report should contain the milestones and deadlines document with completed tasks checked off.
- b) Satisfactory progress may be demonstrated by successful completion of course work, completion of appropriate examinations and papers, and progress in choosing a research project, performing the research work, and writing the dissertation.

- c) Each year, normally not later than June 1, the progress of all graduate students will be evaluated by the graduate ECE faculty. Each student will be informed of the results of this evaluation, if the progress is judged to be inadequate. A Ph.D. student not making satisfactory progress toward the degree may be dismissed from the program as a result of this evaluation. Any final decision to drop a student from the program will be made by vote of the department's graduate faculty.

8) Ph.D. Preliminary Examination:

The purpose of the preliminary examination is to identify those students who are qualified to work towards the Ph.D. degree in Electrical and Computer Engineering. It is designed to evaluate the primary characteristics necessary for research, including logical thought, curiosity, motivation, technical insight, the ability to answer questions, and to communicate technical ideas, both verbally and in writing. Each student, including teaching assistants, must participate in a faculty-directed research project which is sufficiently technical to be presented for the preliminary exam. The examination will be offered in both the fall and spring semesters. The exam comprises a research paper and an oral presentation.

a) Eligibility.

To be eligible to take the exam, the student must earn a grade of B- or better in each of three gateway courses (See Section 3.b) with an average grade over the three of B or higher. Failure to do so will result in the dismissal of the student from the ECE Ph.D. program. Students with a Master's degree who transfer in to the Ph.D. program may, with the approval of the advisor and DGS, use courses from their MS degree to meet the gateway course requirements. If there is a deficit of such courses in the student's MS degree, remaining gateway courses must be taken during the student's first year of study in the Ph.D. program.

The preliminary exam should be taken after completing 18 hours of coursework and before completing 24 hours of coursework (usually the third semester of study). A student must register to take this exam with the ECE DGS at least six weeks prior to the exam. Upon registration, the student must inform the DGS of his/her main area of research.

b) Exam Committee.

The committee is appointed by the DGS and consists of four faculty members to include the candidate's faculty adviser of record and at least one faculty member from outside the candidate's core research area.

c) Exam Components.

The exam comprises a research paper and an oral presentation.

i) Research Paper.

The student must deliver a written document to the exam committee no later than 2 weeks before the scheduled date of the exam. This document can be either

(1) A peer-reviewed conference or journal paper on a topic relevant to the student's plan of study, on which the student is the primary author, and has been published or accepted for publication by a reputable conference or journal, or

(2) A solely authored research paper similar in form to a scientific paper, including formatting, figures (as necessary), and literature citations. A description of original research is welcomed but not required. The topic of the paper must be approved by the student's advisor. The topic can be interpreted broadly. Examples of acceptable topic areas are (1) a description of research performed by the candidate, along with sufficient background to demonstrate an initial understanding of the work and its context in the field, (2) a review of relevant literature that may provide useful background for the candidate's future research, or (3) a paper that describes a scientific instrument in sufficient detail to demonstrate the candidate's knowledge of its functions and practical use. The paper must be written clearly in English using the single-spaced 12-point font, Times New Roman, with 1-inch margins. The length should be between 2000 and 4000 words. The document should include appropriate figures, tables, and citations, which do not count against the word limit. Any material from outside sources must be fully and appropriately referenced. Documents not meeting the specified criteria will be returned without review.

ii) Oral Presentation.

At the beginning of the exam the student will present a scientific talk of no more than 30 minutes duration on the subject of the research described in the paper. Committee members will question the student on the research, its technical basis and background, and its implications. General questions to test the student's knowledge of the research area and to evaluate the student's ability to answer questions are likewise permissible. The student may be asked to work a problem or demonstrate a concept on the board during questioning.

iii) Evaluation.

Individual committee members will judge the student as either passing or failing the exam considering both the research paper and the oral presentation. Each member will base their evaluation on all relevant aspects of the student's work including demonstrated knowledge, the technical and expository quality of the paper, the technical quality of the presentation, and the student's response to questions. Three of the four committee members must score the exam "Pass" for the student to pass the exam.

d) Timing / Logistics: Oral exams will be given in fixed, two-week periods in October and in April. Students who do not pass on the first attempt may take a second (and final) exam given during the exam period of the next semester. Students failing the exam twice will

be dismissed from the program. There are no exceptions to the schedule without DGS and Department Chair approval. Transfer students with an MS degree must take the exam during or immediately after their first year of study in the Ph.D. program. Scheduling exceptions will only be granted in extraordinary circumstances.

9) Ph.D. Qualifying Examination and Major Area Paper.

The Qualifying Exam for ECE comprises a major area paper (MAP) and an oral examination given by the student's PhD committee. The exam is normally taken during the third year of study, after 36 hours of course and research work. The MAP is a document written by the student that summarizes his/her research to date, proposes research for the completion of the degree, and provides a timeline for its completion. The student must form a PhD committee of at least five graduate faculty as described in Section 2. A "Request to appoint Ph.D. committee" form obtained from the Graduate School must be filed at least 3 weeks before the exam. After formal acceptance of that form, the student must schedule the exam at a time acceptable to the entire committee. A "Request to schedule qualifying exam" form obtained from the graduate school or the ECE graduate coordinator must then be filed and accepted at least 3 weeks prior to the exam. Two weeks prior to the exam date the student must deliver a copy of the MAP to each committee member. The written and (or) oral exam is to demonstrate the student's competence in his or her area of specialty. The nature of this exam is at the discretion of the student's committee. The oral defense of the major area paper is not limited to the topic of the paper, but may also include knowledge relevant to the student's research. The area paper will be judged by the following criteria. It will:

- a) Identify and explore a significant research area.
- b) Contain a comprehensive review of the research literature relevant to the area.
- c) Demonstrate the student's thorough familiarity with the literature and with the concepts and methods pertinent to conducting research in the area.
- d) Have the scope, length and critical perception of issues of major review articles in leading journals.

At completion of the oral defense of the major paper, the student's committee will judge the student's performance on the qualifying examination. One of the following determinations will be made and transmitted to the student and the DGS office:

- a) The student has passed the qualifying examination requirements.
- b) The student must retake all or part of the qualifying examination. If the student fails the reexamination, it will be recommended to the Graduate School that the student be dismissed from the program.
- c) The student has failed the qualifying examination and the committee recommends to the department's graduate faculty and the department's DGS office that the student be dismissed from the program.

## 10) Dissertation Requirements

- a) At the time of the qualifying examination, the candidate is required to provide his or her Ph.D. committee with a proposal for the dissertation research. This can be part of the MAP. The proposal should state the research problem and specify the methods and procedures to be used. If the candidate has performed preliminary work, the results should be included. The committee may administer a formal oral examination on the proposal (usually as part of the Qualifying Exam) or may elect to have each individual member of the committee pass on the merits of the proposal separately. The DGS office is to be notified of the committee's acceptance of the Ph.D. proposal. (That is usually included in the notice of passing the Qualifying Exam, but can be separate.) The proposal may be modified as research proceeds and new directions are indicated.
- b) After completing the work proposed, the candidate will prepare a draft of the dissertation. The Ph.D. committee chairman will determine when the draft has progressed sufficiently for it to be given to the committee and for an oral examination – the Dissertation Defense – to be scheduled with the DGS and the Graduate School.
- c) The candidate must distribute a final draft, including all figures, tables, appendices and references, to the candidate's Ph.D. committee members two weeks before the scheduled Dissertation Defense oral exam.
- d) At the oral examination, the candidate will be required to defend the dissertation and the work presented in it. The candidate should, in the course of the defense, be able to demonstrate a thorough knowledge of the literature relevant to the area and competence in justifying procedures and interpretations in the work. The results of the examination shall be reported to the graduate school and the DGS office.
- e) If the defense is not satisfactory, the student's Ph.D. committee may require revisions of the draft and a re-examination. In some cases they may require more extensive work by the student.
- f) After approval by the committee, the student will produce a final typed manuscript. This manuscript can either be a monograph or a collection of papers submitted or ready for submission to leading peer-reviewed journals in the student's area of research. If the latter option is taken, the final document should include the manuscript(s) plus a general introduction, a summary, recommendations for future work, and possibly appendices presenting material not included in the manuscripts.
- g) Before the final acceptance of the dissertation, the candidate must present the work at a department seminar and at least one manuscript must have been submitted to a leading peer-reviewed journal in the student's area of research.

## 11) Time Limit

Full-time Ph.D. students are normally expected to have completed all work credited for the doctoral degree within a three-year period from the date of qualification. In all cases, the doctoral degree shall be completed within four years after the candidate passes the

qualifying examination. Candidates not meeting this requirement will be dismissed from the Program or may be required to retake the qualifying examination.

12) Waiver of Requirement

In rare situations, a requirement or requirements for the Ph.D. may be waived. This requires that a faculty advocate present the reasons for waiver to the program faculty. This committee shall accept or reject the proposed waiver or recommend to the student's chairman further action.

13) Residency

Residency requirements must conform to the rules of the Graduate School and the School of Engineering.