



**PennState**

## Graduate Degree Programs in Electrical Engineering



The Pennsylvania State University  
Department of Electrical Engineering  
121 Electrical Engineering East  
University Park, PA 16802

**2021/2022**

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### Department OF Electrical Engineering

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## **I. GENERAL INFORMATION**

### **A. University Policies**

This handbook includes a few of the general University policies that have special relevance to The Department of Electrical Engineering (E E). It does not include all of the policies that can affect your stay at Penn State see <http://www.gradschool.psu.edu/current-students/>  
This handbook does not supersede any general policy of the University.

If you have specific questions, please feel free to Contact SherryDawn Jackson in the Academic Affairs Office, 121 EE East

### **B. Safety and Compliance**

Any questions regarding safety should be directed EE Safety Officer, J.R. Watson 865-5281 or [jlw197@psu.edu](mailto:jlw197@psu.edu).

**EMERGENCIES --- 911**  
**UNIVERSITY POLICE --- 863-1111**

In addition to safety issues, there are federally mandated compliance issues. Filing applications and obtaining approvals for the proposed work must precede any activities involving human subjects, vertebrate subjects, bio-hazardous material, and radioactive materials. Details are available at <http://www.research.psu.edu>

### **C. Scholarship and Research Integrity**

Students are expected to commit themselves to the highest level of ethical conduct in their academic and research activities. All Electrical Engineering graduate students must complete the Scholarship and Research Integrity Requirement (SARI) <http://www.research.psu.edu/training/sari> within their first year of graduate studies at Penn State (see Section II. C. Scholarship and Research Integrity (SARI) Requirement).

### **D. Graduate and Professional Student Association and Other Graduate Organizations**

The Graduate and Professional Student Association (GPSA) <http://gpsa.psu.edu/> provides numerous services and information to graduate students. The GPSA invites graduate students to participate in its meetings and functions.

There are many other student organizations, including the Engineering Graduate Student Council, the student branch of IEEE, hobby and sports clubs, etc. The GPSA is a good source of information.

The EE Graduate Student Advisory Committee (GSAC) provides representation of the graduate student body to the Graduate Program Coordinator and the Department Head, who appoint this committee. The members also organize several events throughout the year to encourage interaction between graduate students in different research groups. The current members of the EE Graduate Student Advisory Committee are:

Reza Janalizadeh Choobbasti ..... rzj12@psu.edu  
 Alex Grede ..... atg324@psu.edu  
 Nina Krainova ..... nuk241@psu.edu  
 Sahar Hojjatinia..... suh434@psu.edu  
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 Mohit Tendulkar..... mbt5208@psu.edu

## II. ADMISSION, ADVISING, SARI REQUIREMENT AND ELECTRICAL ENGINEERING MINORS

### A. Admission to Graduate Programs

Students may be admitted to the MS program, to the PhD program after completing an MS program, or directly to the PhD program, bypassing the MS program. Applicants are expected to have a BS degree in electrical engineering. Exceptional candidates from related fields are also welcome to apply. Only well prepared and highly competitive candidates should apply to enter the PhD program directly from the BS program because they will be required to take the qualifying examinations within one year of entry into the program.

Applicants are required to complete the University's on-line application <http://gradschool.psu.edu/prospective-students/how-to-apply/> which includes information specific to Electrical Engineering. They must provide formal transcripts, general GRE scores, letters of reference, a resume, and a personal statement of technical interests, goals, and experience. International students whose first language is not English must submit a TOEFL score. It should be noted that students admitted to the graduate program who do not demonstrate satisfactory proficiency in English will be required to take additional English and/or speech communications courses.

Students who intend to continue from the MS to the PhD program should apply for change of degree at least three months prior to the transition. An updated personal statement, and a letter from the Department of Electrical Engineering faculty member who will serve as the student's PhD adviser should accompany that request. Standards for entry to the PhD program are generally more rigorous than for the MS program. Satisfactory completion of the MS program does not guarantee admission to the PhD program.

### B. Advising

Academic advising usually comes from the faculty member who supervises the student's research. Other members of the student's thesis committee may also serve as advisers. A newly arriving student will be assigned a temporary faculty adviser who will provide initial advising at the beginning of the first semester. The

graduate program coordinator is available to consult and assist with difficult decisions, please see SherryDawn Jackson for assistance scheduling a meeting if you have a need. Students are encouraged to meet with faculty members in their area of interest and strive to complete a Graduate Student/Faculty Adviser Agreement Form by the end of the first semester.

**C. Scholarship and Research Integrity (SARI) Requirement**

Within the first year all EE graduate students are required to complete the following activities:

- Responsible Conduct of Research (RCR) training provided by the Collaborative Institutional Training Initiative (CITI) on-line <http://citi.psu.edu/>
- 3 hours of program specific, discussion-based training available through special EE colloquia
- 2 hours of discussion-based training facilitated at the University and/or College of Engineering level. For detailed information please see the following web site <https://www.research.psu.edu/training/sari>

**D. Electrical Engineering Minors for Students in Other Fields**

The general requirements for a minor in electrical engineering shall be consistent with those of The Graduate School as stated in the Graduate Degree Programs Bulletin <http://bulletins.psu.edu/bulletins/whitebook/index.cfm>

All graduate students desiring minors in Electrical Engineering shall formally register such minors with the graduate program as soon as the decision to enter such a minor has been made. At the time of registration, a program of study shall be formulated and any departures from these courses must have the approval of the graduate program coordinator and The Graduate School. The electrical engineering MS minor requires 6 credits of 500-level electrical engineering courses. The PhD minor requires 15 credits of electrical engineering courses with at least 12 of the 15 credits at the 500 level.

**E. Area Table**

<b>Specialization Area<sup>1</sup></b>	<b>EE Core Course<sup>2</sup></b>
Communications	560
Computer Vision and Pattern Recognition	560
Networking	560
Signal and Image Processing	560
Control Systems	580
Power and Energy Systems	580
Electro-Optics and Non-Linear Optics	524
Microwaves, Antennas, and Propagation	531
Remote Sensing and Space Systems	531
Circuits and Networks	510
Materials and Devices	542
VLSI	542

1. A student's primary and secondary specialization areas may not have the same core course for the PhD qualifying exam.
2. The specialization area core courses are intended to establish the fundamentals of the technical area.

### **III. MS PROGRAM IN ELECTRICAL ENGINEERING**

The MS degree may fill different objectives. It can be a terminal degree, or it can focus toward preparing for the PhD. The MS degree can be research oriented or it can emphasize graduate level course work. If the student chooses graduate level course work emphasis, they also have the choice of the 1-year MS program track or standard program track (typically two years). These various objectives are possible because of a choice between preparing an MS thesis or an MS paper. Course requirements are different for the two options. Additionally, the standard MS paper option can be completed either by working with an individual research advisor or via a special section of the EE 594 course.

One other option available is that a student who is admitted to the MS program may concurrently pursue a second master's degree. Instructions and application forms are available from the graduate program staff coordinator, 121 EE East. The Dean of The Graduate School must approve concurrent degree program requests for both programs.

Regardless of what options are chosen, several general requirements must be met. At least 50% of the total course credits required (excluding colloquium and research credits) must be electrical engineering courses. The student's program shall include no more than 3 credits of individual studies (596) and only members of the Department of Electrical Engineering graduate faculty may instruct electrical engineering individual studies courses. The undergraduate independent studies course (EE 496) will not count toward the program credit requirements. At most, 9 credits taken at the 400 level may be counted toward the degree requirements, though students can and often do take credits beyond degree requirements. Students may take relevant 400-level and 500-level technical courses from other graduate programs as long as they do not duplicate other course work they have taken and do not exceed the 50% of total course credits. All students are expected to complete one credit of colloquium (EE 500) for two semesters. Degree requirements should be completed during a 6-year period.

Students who have deficiencies in the use of spoken or written English may be required to take courses in these topics in addition to the usual degree requirements.

Courses have been grouped into areas for the purpose of incorporating a breadth requirement into the MS program. These areas are:

- Communications, Computers, Networking, and Signal Processing
- Control and Power Systems
- Electromagnetics and Optics
- Electronics and Photonics

The most recent listing of 500-level courses by area can be found inside the back cover of this booklet. It should be noted that some CSE courses are included in one of the areas. Not all courses are included in the listings. Only these listed courses are acceptable for the breadth requirement. If a student wishes to satisfy the breadth requirement by taking an electrical engineering special topics course (EE 597), it must be approved by the Graduate

Program Committee (by petition to the Committee) prior to scheduling, to be used to satisfy the breadth requirement.

#### **A. Supervision and Advising**

Students will be assigned temporary academic advisers at the beginning of their first semesters, unless they were offered a research assistantship at the time of their admission. The new MS student (standard paper or thesis option) will consult with possible research supervisors to identify a research adviser with whom they will formulate plans, including courses to be taken and the choice between thesis and paper option. The research adviser may suggest and approve relevant technical courses from other closely related departments to be included in the MS program. The student and adviser will also identify other faculty members who will serve on the student's committee. By the end of the second semester, the student should complete the "Option and Committee Membership Approval Form" requesting the approval of the student's committee, tentatively identifying the research topic, and choosing the thesis or paper option. The committee members and the graduate program coordinator ultimately sign the student's thesis or paper approval form.

Students completing the standard MS paper track via the special section of the EE 594 course will be advised by the faculty member conducting EE 594 the semester they are enrolled (see Section III.D).

The 1-Year MS program track students will be advised academically by the 1-Year MS Coordinator and guided for their paper/presentation by an EE graduate faculty member assigned at the time of admission.

#### **B. MS Committee Specifications**

A student's MS committee must have at least two members who are Department of Electrical Engineering graduate faculty and at least one member who is tenured or tenure-track in the Department of Electrical Engineering. The chairperson or one co-chairperson must be a Department of Electrical Engineering graduate faculty member and have a tenured/tenure-track appointment or a joint, courtesy or dual title appointment in the Department of Electrical Engineering. The committee can be chaired by a tenured/tenure-track faculty member from Computer Science and Engineering department, in which case one committee member must be tenured/tenure-track in the Department of Electrical Engineering. All persons serving as chair or co-chair of a committee must be members of the Penn State graduate faculty. The committee may have additional members who are Penn State graduate faculty or who have professorial appointments in the Department of Electrical Engineering or in a department related to the research topic. The committee may also have special members who have expertise in the MS candidate's research area and who would normally carry significant supervisory responsibilities. The special members should hold a PhD degree and must be approved by the EE Graduate Program Coordinator. Members of the Penn State

graduate faculty or persons not affiliated with Penn State who have particular expertise in the student's research area may serve as signatories who will read and approve the thesis or paper but are not required to attend the defense or presentation. The committee must be appointed by the end of the second semester in the program unless the student is completing the MS (paper) via the EE 594 course option (see Section III.D. Paper Option). In this case, the committee is formed during the semester that the course is offered, and no later than the fourth semester in the MS program.

### **C. Thesis Option**

The degree requires 32 credits including 24 technical course credits (50% or more must be EE courses) with at least 15 credits at the 500 level, 2 colloquium credits, and 6 thesis credits identified as EE 600 (thesis research). At least one course must be taken at the 500 level in two of the previously mentioned four areas to complete the breadth requirement. (A list of 500-level courses by area is on the inside back cover of this booklet.) EE 597 courses must be approved by the Graduate Program Committee (by petition to the Committee) prior to scheduling, to be used to satisfy the breadth requirement.

Original research, usually requiring at least two semesters of work (6 credits), is expected for a thesis. The work should be an in-depth investigation intended to extend the state of the art in some specialty area. Mere application of some existing engineering technology is generally not sufficient.

At the beginning of the research, each student should obtain a "Thesis Guide" from the Thesis Office web page <http://www.gradschool.psu.edu/current-students/etd/>. Starting with the correct format will prove beneficial. Thesis deadlines are available at <http://www.gradschool.psu.edu/current-students/etd/thesisdissertationperformance-calendar/>. Committee members may request periodic progress reports that may contain materials that will appear in the thesis. As work is satisfactorily completed, the grade of 'R' is assigned to 600-level credits.

Two weeks prior to the thesis defense, the completed thesis should be delivered to the committee members. Also, at this time, a defense date must be scheduled with the department's graduate program staff coordinator who will provide assistance with the room reservation and publicity for the public presentation. All committee members must attend the defense. Students submitting a thesis or dissertation through the Electronic Thesis and Dissertation Application <https://submit-eta.libraries.psu.edu/main> will have their thesis and dissertation submission digitally signed by their committees via the eTD application. This capability allows a student to securely share their final document with the committee members and allows committee members the ability to review the document and give their approval electronically. (When the department head is appointed as a committee member, the committee must have at least three members or two members and an

approved signatory to satisfy the Thesis Office requirement for three signatures on the thesis.)

#### **D. Paper Option**

The degree requires 32 credits including 27 technical course credits (50% or more must have an EE designation) with at least 18 at the 500 level, 2 colloquium credits, and 3 credits of EE 594 (paper research). At least one course must be taken at the 500 level in two of the previously mentioned four areas to complete the breadth requirement. (A list of 500-level courses by area is on the inside of the back cover of this booklet.) EE 597 courses must be approved by the Graduate Program Committee (by petition to the Committee) before scheduling, to be used to satisfy the breadth requirement.

The paper is intended to be a relatively short document compared to the thesis. Typically, it is the length of a manuscript prepared for submission to a journal. The work should be done while a student is enrolled in the MS program at Penn State. The paper should be written according to the standards set for an IEEE publication and should represent a contribution to a specific engineering activity. It should depict application at the state of the art. Interdisciplinary activity is encouraged.

In conjunction with the paper, the student is required to make a presentation on the work. The student must schedule the paper presentation through the graduate program staff assistant who will arrange the proper publicity and reservations. All committee members must attend the presentation. The paper should be delivered to the committee members and the presentation scheduled at least two weeks prior to the event.

The student must fulfill the 3-credit paper research requirement by registering for EE 594. A grade of 'R' is submitted if the work is satisfactory. When the paper is successfully completed, all committee members and the department head will sign a paper completion report that will be kept with a copy of the paper in the student's file. The student must submit an electronic copy of the final paper to the Department Head, cc'ing the Graduate Staff Coordinator.

Students completing the paper culminating experience using the EE 594 course option must complete the course no later than the fourth semester in the program. The faculty member conducting EE 594 will serve as the Chair or Co-Chair of the student's MS paper committee. The second member of the committee will be a designated faculty member attending the poster session for the student.

The 1-Year MS program track follows the MS paper option requirements and is completed within one year (3 semesters).

The student on this track takes 14 credits fall semester, 15 credits spring semester and 3 credits summer semester (graduation semester).

Fall Semester:

4 courses, 12 credits

EE 500 (Colloquium) 1 credit

EE 594 (Research Projects) 1 credit

Total: 14 credits

Spring Semester:

4 courses, 12 credits

EE 500 (Colloquium) 1 credit

EE 594 (Research Projects) 2 credits

Total: 15 credits

Summer Semester:

1 course, 3 credits

Total: 3 credits

The 1-year MS program track students are ineligible for completing the paper culminating experience using the EE 594 course option.

#### **E. Integrated Undergraduate Graduate MS Degree**

Undergraduate honors students may apply to the EE Graduate Program to earn their MS degree simultaneously with the BS in EE. The following guidelines apply:

- Completion of an MS Thesis with novel content, possibly building on Senior Honor's Thesis, guided by EE graduate faculty member.
- Take GRE no later than the summer after the junior year.
- Completion of the Senior Honor's Thesis by the end of the 8<sup>th</sup> Semester.
- Submission of Senior Honor's Thesis proposal report during either student's 6<sup>th</sup> or 7<sup>th</sup> semester.
- Submission of an MS thesis plan at the time of submission of Senior Honor's Thesis.
- As many as twelve academic credits earned by the IUG Scholar may be applied to both undergraduate and graduate degree programs (double-counted).
- 50% or more of the courses proposed to count for both degrees must be at the 500 level.
- Thesis credits may not be double counted.
- Undergraduate honors requirements must be met by courses listed on your undergraduate transcript.
- When an IUG Scholar completes both the undergraduate and graduate degrees simultaneously, both degrees are in the same program, and where the program

head approves, the master's thesis may be submitted in lieu of the undergraduate honors thesis. Otherwise, two separate theses are required.

#### **F. MS Time Limits**

The Department of Electrical Engineering has established a six-year time limit for completion of the MS degree (with the exception of the 1-Year MS program track).

Standard MS program: Committee must be appointed by the end of the second semester.

1-Year MS program track: Committee must be formed by the end of the first semester.

The thesis defense or paper presentation must be scheduled and a copy of the thesis or paper provided to all committee members at least two weeks prior to the scheduled date.

### **IV. PhD PROGRAM IN ELECTRICAL ENGINEERING**

The doctoral student's goal will be to establish his/her reputation as a researcher with a broad supporting base in laboratory and/or analytical techniques, and with experience in presenting original research results at conferences and in refereed journals. The Department of Electrical Engineering welcomes highly qualified students with BS or MS degrees in electrical engineering, as well as in related engineering and science disciplines. The doctoral students become PhD candidates after completion of several PhD qualification procedures. These PhD qualification procedures, while centered in electrical engineering, are also intended to allow students with diverse backgrounds to efficiently move toward attaining their PhD degrees. To these ends, the student will complete the PhD qualification procedures (Section IV-B-2 of this booklet) to verify a sufficient base of study, be evaluated for English proficiency and presentation skills during a 15-20 minute technical presentation, develop a dissertation proposal to be presented at an oral comprehensive exam (thesis proposal exam), conduct the proposed research, and disseminate the results through the dissertation and related publications. As part of the program, the student will complete 39 technical course credits and 2 colloquium credits beyond the BS degree, with at least 30 of these course credits at the 500 level (i.e., at most 9 credits may be 400 level). No more than 3 of these credits may be individual studies (E E 596) and only members of the Department of Electrical Engineering graduate faculty may instruct electrical engineering individual studies courses. Courses not in electrical engineering require approval of the research supervisor. Undergraduate individual study course (EE 496) will not count toward program credit requirements. A PhD student with graduate credits from other institutions may request the approval of the Graduate Program Coordinator to count related technical course credits toward the PhD credit requirements. A maximum of 24 such credits may be counted. Students with MS degrees entering the PhD program will be required to take a minimum of 15 course credits, with at most 3 credits

at the 400 level and with at most 6 credits outside of EE. At most 3 credits of EE 596 can be counted toward PhD course requirements.

#### **A. Adviser and Committee**

The faculty member who recommended the student for admission will act as the temporary adviser. Students must identify a research adviser before registering for the PhD qualifying exam. Each student is encouraged to visit members of the graduate faculty during the first semester. These visits will assist in the selection of the research adviser and help identify potential committee members. The adviser is expected to be the research supervisor when the student is supported as a research assistant. The student should identify his/her research adviser no later than the end of the second semester after admission as a PhD student and should form a doctoral committee no later than the end of the semester after the student has completed PhD qualification procedures. The committee will consist of at least three members of the Department of Electrical Engineering graduate faculty and one non-electrical engineering graduate faculty member. At least two members must be tenured/tenure-track in the Department of Electrical Engineering. The chairperson or one co-chairperson of the committee must be a Department of Electrical Engineering graduate faculty member and have a tenured/tenure-track appointment or joint, courtesy or dual title appointment in the Department of Electrical Engineering. The committee can be chaired by a tenured/tenure-track faculty member from Computer Science and Engineering department, in which case at least one committee member must be tenured/tenure-track in the Department of Electrical Engineering. Either the chairperson or one of the co-chairpersons will normally be the primary research supervisor. In addition to the chairperson, at least two members of the doctoral committee should have a specific interest in the dissertation or in a closely related area. Additional graduate faculty and/or special members (as defined in the Graduate Degree Programs Bulletin <https://bulletins.psu.edu/graduate/> and approved by the Dean of The Graduate School) may be appointed to the committee. The committee must be recommended by the Department and appointed by the Dean of The Graduate School. The student must request the appointment of the committee through the graduate program staff coordinator. If a student wishes to change his/her adviser to a new adviser, a written notification must be submitted to the department head. This petition must be reviewed and approved by the new adviser.

#### **B. PhD Qualification Procedures**

Admission as a PhD student does not imply admission to PhD candidacy, which is granted only by the EE Graduate Committee after the student completes all the PhD qualification procedures. The decision for or against completion of these requirements is reported to The Graduate School. Positive recommendations are entered on the transcript, but failures are not recorded.

## **1. Eligibility**

Only registered PhD students with a GPA of at least 3.0 are eligible to become PhD candidates. A student must complete all PhD qualification procedures no later than the beginning of the fourth semester (excluding summer) after entry to the PhD program.

## **2. Procedures**

Each student in the PhD program is required to complete the following components of the EE PhD qualification process:

- Successful completion of the designated core courses in their primary and secondary areas of specialization (a grade of B or better is expected) - the area table is in Section II-E of this booklet.
- Successful completion of 3 credits of EE 596 research immersion course (a grade of B or better is expected).
- Written or oral qualifying exam in the primary area of specialization.

Please note: the majority of core courses are offered fall semester only; core courses taken at Penn State Harrisburg can be used to satisfy the PhD qualification requirements.

Each student in the PhD program is required to complete a qualifying exam in his/her primary specialization area. The purpose of the qualifying examination is to assess whether the student is capable of conducting doctoral research based on evidence of critical thinking or other measures that the Electrical Engineering Graduate Faculty view as important to a successful doctoral student. The format of the exam is determined by faculty members responsible for the primary core course in the specialization area chosen by the student. This may be a written exam, an oral exam, or a combination of the two. Each student must submit a qualifying exam registration form to the EE graduate program staff coordinator at least two months prior to the scheduled date of the exam, and no later than the end of the second semester in the PhD program (form available from the graduate staff coordinator).

A written qualifying exam will be composed of 6 questions from the student's primary specialization area (Area Table, First Column). Students will be required to answer at most 5 of 6 questions. However, areas conducting the exam may allow students to answer all 6 questions, in which case the 5 answers with the highest scores will be counted toward the final grade. The questions will be based on fundamental material found in the core course and the respective prerequisite courses for the student's primary specialization area (Area Table, Column 2). The exam duration will be four hours. No books or notes will be allowed unless indicated otherwise. Students should bring pens or pencils, erasers, and simple calculators (not memory storage or internet access devices), but no paper. Each problem will be scored from 0 to 10 with an overall score of 70% being the minimum passing grade.

An oral qualifying exam will be administered by a committee of at least three tenured or tenure-track faculty members in the department, including the student's adviser. The student will be informed about the specifics of the oral exam format no later than one month prior to the exam. The questions during the exam will be based on fundamental material found in the core course and the respective prerequisite courses for the student's primary specialization area (Area Table, Column 2). At the completion of the exam each committee member will submit a score from 0 to 10, with 7 being the minimum passing grade, reflecting the student's performance during the exam.

A student may review his/her written test or discuss his/her performance during the oral exam with the qualifying exam coordinator. No student is permitted to personally contact the faculty members who graded the exam questions or served on the oral exam committee. If a student wishes to dispute the outcome of an exam, he/she must submit a written petition to the qualifying exam coordinator, who will then contact the student after the re-evaluation is completed.

The written and/or oral examinations will be scheduled for the 2nd week of classes during the Fall and Spring semesters.

The graduate committee will consider the two core course grades, the EE 596 research immersion course grade and the qualifying exam score in making the decision regarding completion of PhD qualification procedures.

Students who do not pass the written or the oral qualifying exam must take it again the next time it is offered. Students who are unsuccessful in their second attempt will be disqualified from the PhD program in EE.

### **3. Appeals**

The graduate committee will consider student petitions giving special attention to inputs from the student's area faculty and research adviser. The primary criteria that the graduate committee will consider will be based on evidence of quality of accomplished research and potential for future research. This evidence should include statements by at least one and preferable two EE professors commenting on past and expected research, as well as a list of papers published or accepted for publication in refereed journals or conferences. The primary evidence can be strengthened by a statement of willingness of a faculty member to provide supervision and financial support for the candidate's research. The graduate committee will also consider GPA, EE research immersion and core course grades, written and/or oral qualifying exam scores and improvement in performance from the previous exam. Proximity to the pass threshold is not by itself sufficient grounds for reversing a decision.

## **C. Communication and Language Competence**

The PhD student shall demonstrate competence in the use of the English language for purposes of both written and oral communication. He/she should be able to communicate technical material in a clear, concise, and well-organized manner. The research adviser or the doctoral committee may require that the student take formal courses in technical writing, speech, etc., if it is determined that the communication skills are inadequate. There will be various communication experiences throughout the program, starting at the beginning of the first semester at Penn State.

### **1. Writing Requirements**

PhD students who have completed all PhD qualification procedures and have been admitted to PhD candidacy must take a test of written English. This test is given during the spring semester every year and is scheduled by the EE Department. Non-native English speakers who have successfully completed ESL 116G or native English speakers who have successfully completed a technical writing course (ENGL 202C at Penn State or an equivalent course at another institution) will be exempt from this test. Students who fail the test will be required to take ESL 116G (B or higher required).

Students are expected to gain further writing experience by preparing research reports, conference papers and refereed journal articles as they report on their original findings before their final defense. The doctoral committee is expected to review and critically evaluate any of the student's written work, including the dissertation proposal, interim reports and manuscripts.

The dissertation is to meet the standards set forth by The Graduate School and is to be evaluated by the doctoral committee for the quality of the writing as well as technical content. At the beginning of the research, each student should access the Thesis and Dissertation Guide <http://gradschool.psu.edu/current-students/etd/> insuring that the written or graphical materials generated from time to time can be in the format acceptable to The Graduate School.

### **2. Oral and Presentation Requirements**

All international PhD students will be interviewed at the beginning of their study for evaluation of oral English skills. Those who have deficiencies will be required to take ESL (English as a second language) courses during their first year (preferably their first semester). Those who score at least 220/300 on the Penn State American English Oral Proficiency Test will not be required to take ESL courses for oral English. However, students who would like to be considered for teaching assistantship positions must score

at least 250/300 in the test or successfully complete ESL 118G. During the first year, students whose first language is not English must demonstrate speaking and listening skills.

Presentation skills of all PhD students will be evaluated after formal completion of all procedures required for admission to PhD candidacy. Each student will make a 15 to 20 minute presentation on a technical topic to a group of students and faculty including their research adviser. This presentation will be coordinated by the research adviser and should take place no later than the first semester after passing the qualifying exam. Students found to have deficiencies in presentation skills will be required to take a course to develop these skills.

The student will make an oral presentation of approximately 30-minutes in length to the doctoral committee on the dissertation problem and the approach to its solution. This thesis proposal presentation is a part of the comprehensive exam.

After completion of his/her comprehensive exam, the student is required to present a poster during the undergraduate research fair. The student is also encouraged to travel to conferences to make oral presentations of his/her work.

In addition, an oral presentation on the results of the dissertation research is required. This presentation will be a part of the final dissertation defense.

#### **D. Comprehensive Exam**

The PhD candidate will take the comprehensive exam following completion of all course work required for the PhD (39 course credits past the BS degree) and submission of the PhD proposal to his/her committee members. The student will be responsible for determining a time for the exam that is acceptable to the committee. The student will then contact the graduate program staff assistant for appropriate forms and to schedule a presentation room. The graduate program coordinator will request that the dean of The Graduate School schedule the exam. The student must see the graduate staff assistant to schedule the exam at least three weeks prior to the exam date. The dissertation proposal must also be submitted to the doctoral committee at that time (as each committee member prefers, either electronically or as a hard copy). The exam may be canceled if the proposal is not delivered to committee members at least three weeks prior to the exam date.

A thesis proposal is required for the comprehensive exam. Though the nature of this proposal is under the jurisdiction of the doctoral committee, it is recommended that it should be prepared by adhering to the guidelines provided for research proposals submitted to such agencies as the National Science Foundation. That would require limiting the size of the main body of the proposal to the equivalent of fifteen single-spaced pages of text. This proposal should contain, as a minimum,

the background and motivation for the research being undertaken, the specific problems to be tackled, and the approach as well as methods to be adopted for attempting the solution together with a summary of any preliminary results. Any additional material that does not belong to the core of the proposal, but provides either justification of the proposed scheme or documentation of preliminary efforts, could be included in an appendix.

All members of the committee must participate in the comprehensive exam. One committee member (not the chair) may participate by teleconference or skype in special circumstances. Permission for distance participation must be obtained from The Graduate School prior to the exam date (see graduate staff coordinator to request permission). The student and at least three members (including the chair) must be physically present at the exam.

The graduate staff coordinator will submit this request (signed by the graduate program coordinator) for scheduling the comprehensive exam when:

- the committee has been appointed;
- the committee members have approved the date;
- all conditions stipulated after the qualifying exam have been met;
- any required English courses have been completed.

The comprehensive exam will consist of three parts:

- the oral presentation of the thesis proposal (including a discussion of the importance of the problem and the current state-of-the-art in related areas);
- the oral examination by the doctoral committee which will seek to determine the student's qualifications to pursue the proposed dissertation research, i.e., the preparation in the appropriate specialized and related areas, and the student's general background and knowledge;
- the committee's verbal evaluation of the student's progress and recommendations for any additional course work and research.

Upon completion of the comprehensive examination, the chairperson of the student's doctoral committee will return "The Report on Doctoral Comprehensive" form with all committee members marked evaluation and signature to the graduate staff coordinator who will submit it to the Graduate School. The Graduate School requires a favorable vote of at least two-thirds of the committee for passing this examination.

Students who have passed the comprehensive exam and who have met the residency requirement may register for EE 601 in subsequent semesters. This is an inexpensive way to register as a full time student. Such a student may take 3 additional credits with reduced tuition or 3 additional credits for audit with no extra charge.

## **E. Final Oral Exam**

The final oral exam must be completed within 8 years of completion of all PhD qualification procedures and within 6 years of passing the comprehensive exam. A minimum of three months must have elapsed since the comprehensive exam. At least 3 weeks before the Final Oral exam, the student must see the graduate staff coordinator for the forms necessary to officially schedule the final oral exam. One of the forms the student will receive will be verification by the adviser's signature that the thesis is ready to be distributed to the other committee members and ready to be defended. At least three weeks before the exam date, the student will distribute copies of the thesis to the committee members. The exam may be canceled if documents are not delivered to committee members at least three weeks prior to the exam date. The graduate staff coordinator will verify that all requirements have been met and will obtain the graduate program coordinator's signature and send the request on to the Graduate School.

The Graduate School sends the Final Oral Exam Report form to the graduate staff coordinator indicating that the exam has been officially scheduled. This examination, open to the public, relates in large measure to the dissertation but may cover the entire field of study. The doctoral committee determines the exact examination procedure. All members of the committee must participate in the final oral exam. One committee member may participate by teleconference or skype in special circumstances. Permission for distance participation must be obtained by the graduate program staff coordinator from The Graduate School prior to the exam date. The student and at least three members (including the chair) must be physically present at the exam. After the defense, the committee chair will return the "Report on the Final Oral Exam" form with all committee members' marked evaluation and signature to the graduate staff coordinator who will submit it to the Graduate School. A favorable vote of at least two-thirds of the members of the committee is required for passing. If the student fails, it is the responsibility of the doctoral committee to determine whether or not another examination may be taken. The approval of the dissertation rests entirely with the doctoral committee and the department head. Effective Fall 2019 semester, students will have their thesis and dissertation submissions digitally signed by their committees and the department through the Electronic Thesis and Dissertation application.

Final oral exams and dissertation submissions must meet The Graduate School's published deadlines for graduation.

## **F. Other Constraints**

To be eligible for the qualifying, comprehensive, and final oral exams, a student must have a minimum grade point average of 3.0, must be registered, must have no missing or deferred grades, and must have satisfied any provisional requirements for admission.

Over some twelve-month period, while enrolled in the PhD program, the student must be registered for full-time academic work at the University Park campus for at least two consecutive semesters (excluding summer).

After passing the comprehensive exam, a student must maintain continuous registration for each fall and spring semester until they defend their thesis. Students who fail to register will be assessed tuition for any semesters in which they did not register before being permitted to continue their PhD studies.

## **G. PhD Time Limits**

### **Area Selection**

The primary and secondary specialization areas for PhD qualification procedures must be declared in writing by submitting the Qualifying Exam Registration Form to the EE graduate program office no later than the end of the second semester after admission into the PhD program. The specialization areas may not have the same core course.

### **PhD Qualification Procedures**

A student must complete all PhD qualification procedures no later than the beginning of the fourth semester (excluding summer) after entry to the PhD program. Each student must submit a qualifying exam registration form to the EE graduate program office at least two months prior to the scheduled date of the exam, and no later than the end of the second semester in the PhD program.

### **Committee Appointment**

A student's PhD committee must be appointed no later than the end of the following semester (excluding summer) after completion of the PhD qualification procedures.

### **Comprehensive Exam**

The comprehensive exam may be scheduled only after the student has completed all required course work (39 credits beyond BS), received English proficiency certification, and satisfied all conditions stipulated during the test of English proficiency and presentation skills. (The dissertation proposal must be provided to the members of the PhD committee and the comprehensive exam must be scheduled with the graduate program staff coordinator at least three weeks prior to the exam date.)

### **EE 601**

Registration for EE 601 is permitted only for semesters following the semester in which the student has passed the comprehensive exam and met the residency requirement. A student may register for EE 601 (full time dissertation research, zero credits) to maintain the required continuous registration between the comprehensive and final oral exams at reduced tuition.

### **Final Oral Exam**

The final oral exam must be scheduled no less than 3 months or no more than 6 years after passing the comprehensive exam. (The thesis must be provided to the members of the PhD committee and the final exam must be scheduled with the graduate program staff coordinator at least three weeks prior to the exam date.)

### **Program Time Limit**

A doctoral student must complete the program and submit an accepted thesis within eight years of completing all PhD qualification procedures.

## **V. POLICIES FOR GRADUATE ASSISTANTS**

Graduate assistant policies from several sources are summarized here for easy reference. Some of the relevant sources that will take precedence if this summary is found to be unclear are the Graduate Degree Programs Bulletin and University Policy PR-6.

### **A. General Policies**

#### **1. Types of Appointments**

The typical Assistantship Appointment (RA or TA) in EE is a half-time appointment, which requires 20 hours of work per week. The pay rates may vary depending on the nature of the job and the student's experience. The assistantship pays the student's tuition (must be registered for 9-12 credits per semester), 80% of the student's health insurance premium and a monthly stipend during the period of the appointment. All appointments automatically terminate at the end of the spring semester, if not before, and appointments carry no guarantee of renewal. Students who have had appointments for both the preceding fall and spring semesters are eligible to apply for summer tuition assistance if they need to be registered for summer.

Appointments may be for a variety of duties generally classified as research (RA) or teaching (TA). Teaching appointments will be supported by internal funds. Research appointments may be supported by either internal funds or externally funded research. The latter is more common. Some appointments may be supported by two sources of funds in which case the service is to be split in proportion to the funds from each source.

A graduate assistant is not eligible for other forms of employment such as part-time hourly wage payroll, either within or outside of Penn State, unless approval is obtained from those supplying the assistantship, the graduate program coordinator, and the college dean. However, a graduate assistant is allowed to receive fellowship funds in addition to the assistantship.

## **2. Periods of Service**

Unless specified otherwise, a semester appointment requires 18 weeks of service and a summer appointment requires 12 weeks. A full year's appointment will then be 48 weeks. It is notable that class is in session for a total of only 44 weeks including exam periods. Research assistants work independently of the academic calendar, more or less, while the responsibilities of teaching assistants are concentrated during the weeks when class is in session. Teaching assistants may have pre-class preparation as well.

## **3. Health Insurance**

All graduate assistants must have health insurance. A person may choose to purchase insurance separately, in which case they must provide proof to the Student Insurance Office in the Student Health Services Building that the insurance meets Penn State standards. This must be done within the first 2 weeks of fall semester otherwise a student is automatically enrolled in a group health insurance policy, vision care policy, and dental insurance plan for graduate assistants and will pay 20% of the premium through payroll deduction. When requested, health insurance and dental and vision care insurance for the student's eligible dependents may be included and the student pays 30% of the premium for dependent coverage. Because the details are too numerous to be repeated here, the student should go to the Student Health Center Building or call 814-865-7467 for information.

## **4. Pay Periods**

Stipends are deposited electronically the last working day of the month to the student's bank account indicated on the salary deposit information they submitted during their on-boarding process. A new arrival likely will not receive the first paycheck on time unless prior processing of the appointment has occurred, however, they will receive the stipend amount for the first and second months of the assistantship at the second pay period.

## **5. Supervision and Evaluation**

Each graduate assistant is assigned to a supervisor, usually a faculty member, who has the responsibility to specify the requirements of the position, to oversee the assistant's work on some regular schedule, and to evaluate the assistant's work, dependability, and readiness to move to higher levels of responsibility.

## **6. State and Local Tax Deductions**

The University will not withhold state and local tax from assistantship stipends when a student is only performing services that are required of all degree candidates in his or her program (only RA positions in EE).

### **B. Teaching Assistant Policies**

#### **1. Preparation and Training**

Electrical Engineering has a positive history of teaching assistant performance in various capacities including classroom instruction. Student complaints about teaching assistants are not frequent and some have achieved unusually high student ratings for their services. We are careful in our selection of persons to serve and we strongly advocate preparation and training for specific jobs. Both supervisors and teaching assistants are responsible for ensuring that teaching assistants are properly prepared for their assignments.

During the first semester, a new teaching assistant is expected to enroll in ENGR 888. This is a one-credit course that provides teaching assistants with the opportunity to learn some pedagogy and to discuss problems that arise in the classroom. In this course, teaching assistants can present talks relevant to their assignments and receive feedback from other assistants who are in similar situations.

Teaching assistants should expect to have meetings with their immediate supervisors prior to the start of the semester, and often during the semester. At the beginning, the teaching assistants should receive a course syllabus, a text, any information to be distributed to students, and specific details about their assignments. Teaching assistants and supervisors are to discuss the instructional goals and objectives of the course and the means to accomplish them. Periodically, meetings should be held to emphasize the purposes of a particular lab or project and how it should be evaluated. Teaching assistants should expect to attend course lectures, especially the first time assigned to a course, to be aware of the instructor's emphasis and expectations of the students.

State law requires teaching assistants whose native language is not English to pass a test of their ability to converse in English, the American English Oral Communication Proficiency Test (AEOCPT). This department appoints only those who have already passed the test that is administered by Penn State's Department of Applied Linguistics. Students who need to take the AEOCPT should see Mariah Drapcho to be scheduled.

## **2. Responsibilities**

Teaching assistants may expect a wide variety of assignments including the following: grading homework, projects, and exams; preparing assignments; preparing solutions for posting or distribution; maintaining office hours and holding help sessions; substituting as lecturers when faculty members are out of town; helping to administer exams including evening exams and exams in courses other than the primary assigned course; preparing and setting up demonstrations; processing grade data and, in some cases, assigning grades. Teaching assistants are advised to keep a daily log of time devoted to the job and how it divides among various tasks.

Teaching assistants should not be asked to do the following: choose textbooks; prepare a syllabus; lecture regularly; teach a new course; help with a professor's work that is unrelated to the course; or meet with a supervisor outside of the hours from 8:00 a.m. - 5:00 p.m. except for formally scheduled exams.

## **3. Absences**

From time to time, teaching assistants must be absent from an assigned job, yet clearly an unmet class represents a major lapse in responsibility and it creates a very poor image of the department among the student clientele. In case of illness or planned absences such as professional trips, teaching assistants should notify the supervisor at the first knowledge of such absence and work with the supervisor to have the responsibilities covered. It is common for two individuals, students or faculty, to arrange mutual exchanges of responsibilities from time to time to allow for such personal needs. Any emergencies or extended changes should come to the attention of the Director of Academic Affairs who may need to reassign jobs.

## **4. Evaluations**

During the first week of the semester, the teaching assistant and supervisor should meet to assure that start-up details have been completed. Late in the semester, any teaching assistant who has had contact with students will have an SRTE (Student Rating of Teaching Effectiveness) evaluation. Additional information and evaluation guidelines are available from the Schreyer Institute for Teaching Excellence or on their web page at <http://www.schreyerinstitution.psu.edu/events>

## **C. Research Assistant Policies**

### **1. The Research Assistant Appointment and Thesis Preparation**

Because a research assistant appointment is normally accompanied by the preparation of a graduate thesis, the research supervisor is usually the thesis

supervisor and will have much to say about related course work and other aspects of the research assistant's preparation. The dual aspects of the appointment cannot be separated. Likewise, the evaluation of the research assistant cannot be separated from the evaluation of the thesis preparation. All that can be asked is that the combination of research appointment and the registration for thesis credits represents a realistic workload, especially in light of other course work the research assistant may be carrying.

## **2. Work Hours**

The nature of the work may well require that hours be spent outside of the normal 8:00 a.m. - 5:00 p.m., Monday-Friday schedule. An obvious example is lidar work that must be conducted at night. Lab tests or experiments may require continuous supervision for an extended period of time. Those who accept research assistant positions do so understanding that unusual hours may be expected. No graduate student, research assistant or otherwise, should expect to be placed in a situation of personal danger by being asked to work alone in a laboratory with a hazardous environment or by being asked to work in an environment where that person might be exposed to harassment or assault from fellow workers or strangers. Supervisors are to be sensitive to such issues and to arrange work schedules to provide necessary safeguards for all individuals involved in the work. Concerns should be brought to the supervisor's attention immediately and to the department head if not promptly resolved.

## **3. Responsibilities**

Research assistants may be expected to do any of the following: maintain hardware or software; clean equipment and work-spaces (but not provide janitorial services); follow prescribed lab and safety procedures; prepare proposals; prepare reports and related graphics; collect and process data; interact with sponsors and vendors; and attend meetings and seminars. Research assistants should not be expected to travel without advances and reimbursement for expenses, to lecture for the supervisor, except for occasional substitutions, or to provide services unrelated to University business, such as consulting or moving household furniture.

## VI. Electrical Engineering Department Graduate Faculty

### Graduate Faculty - Tenured or Tenure Track in the Department of Electrical Engineering

Aydin, Kultegin	129 EE East	863-2788
Breakall, James K	225 EE East	865-2228
Cadambe, Viveck	111J EE West	867-4774
Chaudhuri, Nilanjan	315 EE East	865-2359
Chu, Rongming	N-237 MSC Bldg.	863-3136
Cullina, Daniel	111H EE West	863-9885
Doherty, John F	227B EE West	863-8102
Ebrahimi, Aida	111j EE West	865-6177
Ghosh, Swaroop	319 EE East	865-1298
Giebink, N. Christopher	209H EE West	865-2229
Guan, Weihua	111F EE West	867-5748
Higgins, William E	209F EE West	865-0186
Huang, Shengxi	N321 MSC Bldg.	863-6711
Huff, Gregory	303 EE East	863-2226
Li, Bin	320 EE East	865-3912
Li, Yan	314 EE East	863-9571
Jackson, Thomas N	216 EE West	863-8570
Kane, Timothy J	212 EE East	863-8727
Kang, Lei	301 EE East	865-2776
Kayyalha, Morteza	111G EE West	865-0776
Khoo, Iam-Choon	216 EE East	863-2299
Khoshkbar-Sadigh, Arash	319A EE East	863-2337
Kiani, Medhi	111H EE West	867-5753
Lagoa, Constantino	205 EE West	865-0244
Lee, Wooram	313 EE East	863-0131
Li, Yan	314 EE East	863-9571
Lopez, Daniel	N-321 MSC Bldg.	867-1575
Liu, Zhiwen	N211 MSC Bldg.	865-2362
Miller, David J	227C EE West	865-6510
Monga, Vishal	103 EE East	863-1267
Narayanan, Ram	202 EE East	863-2602

Ni, Xingjie	314 EE East	865-3361
Pasko, Victor	211B EE East	865-3467
Schiano, Jeffrey L	227D EE West	865-5422
Sengupta, Abhronil	111K EE West	867-4476
Sun, Ying	111F EE West	867-4033
Uchino, Kenji	134 MRL	863-8035
Urbina, Julio	315 EE East	865-5326
Werner, Douglas H	211A EE East	863-2946
Yang, Jing	228B EE West	863-8732
Yin, Shizhuo	217 EE East	863-4256
Zhang, Qiming	N219 MSC Bldg.	863-8994
Zhu, Minghui	227E EE West	865-5315

#### **Electrical Engineering Graduate Faculty with Joint Appointments**

Bilén, Sven	213N Hammond /313 EE East	863-1526/8684
Kesidis, George	338J Westgate Bldg.	865-9190
Liu, Yanxi	W372 Westgate Bldg.	865-7495

#### **Electrical Engineering Graduate Faculty with Courtesy Appointments**

Campbell, Sawyer	327 EE East	865-2212
Das, Saptarshi	N333 MSC Bldg.	863-2639
LaPorta, Thomas	207 EE West	865-6725
Mohney, Suzanne	202A Steidle Bldg.	863-0744
Narayanan, Vijaykrishnan	W323 Westgate Bldg.	863-0392
Zhang, Nanyin	W341 MSC Bldg.	867-4791

#### **Electrical Engineering Graduate Faculty from other Departments and Colleges**

Awadelkarim, Osama O	212 Earth & Eng. Sciences Bldg.	863-1773
Barlow, Jesse	343G Westgate Bldg.	863-1705
Bristo, William	621 Walker Bldg.	863-3932

Cao, Guohong	354G Westgate Bldg.	863-1241
Collins, Robert T.	354H Westgate Bldg.	863-1944
Das, Chitaranjan	354F Westgate Bldg.	865-0194
Dey, Satadru	132 Reber Building	865-2519
Furer, Martin	346F Westgate Bldg.	863-1857
Hallgren, Sean	348A Westgate Bldg.	863-1265
Hannan, John	360C Westgate Bldg.	863-0702
Huang, Tai-Yin	Penn State Lehigh Valley	610-285-5100
Jaeger, Trent	346A Westgate Bldg.	865-1042
Jenkins, David	5130A ARL Bldg.	863-6319
Kifer, Daniel	360F Westgate Bldg.	863-1186
Lee, Wang-Chien	360D Westgate Bldg.	865-1053
Madduri, Kamesh	343E Westgate Bldg.	865-0883
McDaniel, Patrick	360A Westgate Bldg.	863-3599
Medvedev, Paul	343G Westgate Bldg.	863-1242
Phoha, Shashi	228 ARL	863-8005
Piovo, Michael J.	Penn State Great Valley	610-648-3200
Ray, Asok	329 Reber Bldg.	865-6377
Redwing, Joan	108 Steidle Bldg.	865-8665
Sampson, John	338H Westgate Bldg.	863-7323
Sivasubramaniam, Anand	354A Westgate Bldg.	865-1406
Troler-McKinstry, Susan	0227N MSC Bldg.	863-8348
Tutwiler, Richard L	165 ARL	863-2188
Urgaonkar, Bhuvan	338D Westgate Bldg.	865-9506
Wagner, Alan	234B Hammond Bldg	865-3138
Werner, Pingjuan L	Penn State DuBois	375-4785
Zhang, Danfeng	338H Westgate Bldg.	863-7323
Zhu, Sencun	338F Westgate Bldg.	865-0995

## **VII. Graduate Program Contact Information**

SherryDawn Jackson, Graduate Staff Coordinator, 118 EE East, 863-7294

Mariah Drapcho, Graduate Admissions Staff Assistant, 121 EE East, 863-7295



### VIII. GRADUATION CHECKLIST FOR M.S.E.E. STUDENTS

\_\_\_\_\_ THESIS - 6 CREDITS OF E E 600 OR \_\_\_\_\_ PAPER - 3 CREDITS OF 594 \_\_\_\_\_ COLLOQUIUM - 2 CREDITS

NAME _____		ID. NUMBER _____	
COMMUNICATIONS, COMPUTERS, NETWORKING, AND SIGNAL PROCESSING	CONTROL AND POWER SYSTEMS	ELECTROMAGNETICS AND OPTICS	ELECTRONICS AND PHOTONICS
CSE 514	E E 580	E E 520	E E 510
CSE 543	E E 581	E E 521	E E 526
CSE 572	E E 582	E E 522	E E 541
CSE 577	E E 584/M E 558	E E 524	E E 542
CSE 578	E E 587/M E 559	E E 531	E E 543
E E 550/M E 550	E E 588	E E 534	E E 544
E E 551		E E 535	E E 545/MATSE 545
E E 552/CSE 583		E E 537	E E 546
E E 553		E E 538	E E 547
E E 554/CSE 586		E E 573	E E 549
E E 555/CSE 585		E E 574	
E E 556		E E 576	
E E 557		E E 579	
E E 560			
E E 561			
E E 562			
E E 564/CSE 554			
E E 565/CSE 515			
E E 567			
E E 568			
E E 569			
<p>Only courses listed above may be used for the breadth area requirement.                      As an exception, EE 597 (X) courses must be approved by the Graduate Program Committee (by petition to the Committee) <u>prior to scheduling</u> to be used to satisfy the breadth requirement.</p>			
List EE 597 Courses:		<b>Scholarship and Research Integrity (SARI)</b> 3 hrs of program specific & 2 hours of general discussion-based instruction plus on-line CITI component.	
List 400 level EE courses (maximum 9 credits, 496 not counted)	List EE 596 course (maximum 3 credits)	List external university transferred credits	Related 400 & 500-level (no 496 or 596) non-EE courses (advisor approval required, <u>these courses will not count toward EE breadth requirement.</u> )
<b>M.S. THESIS OPTION</b>	<b>32 credits</b> (24 course credits, 6 thesis research credits, and 2 colloquium credits)	<b>500-level minimum 15 course credits</b>	<b>Thesis Defense</b>
<b>M.S. PAPER OPTION</b>	<b>32 credits</b> (27 course credits, 3 paper research credits, and 2 colloquium credits)	<b>500-level minimum 18 course credits</b>	<b>Paper Presentation</b>
<b>ALL M.S. STUDENTS</b>	50% of the required course credits must be <u>Electrical Engineering Department</u> courses (excluding colloquium and research)	For the breadth requirement, a 500-level course from at least two of the four areas listed above must be successfully completed.	<b>Time Limit</b> Standard MS track - 6 years 1 Year MS track - 1 year (3 semesters)