EE:Systems

Graduate Program Manual

www.eecs.umich.edu

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INTRODUCTION

The Electrical Engineering:Systems (EE:S) Graduate Program Manual provides information on the requirements for the Master of Science (MS) and Doctor of Philosophy (PhD) degrees. The EE:S Graduate Program is one of three graduate programs comprising the Electrical Engineering and Computer Science Department (EECS) at the University of Michigan. Each of the three programs, Computer Science and Engineering, Electrical Engineering, and Electrical Engineering:Systems has its own areas of research and courses. Students enrolled in EE:S are primarily interested in the area of Systems Science and Engineering.

The EE:S Graduate Program is part of the University of Michigan’s Horace H. Rackham School of Graduate Studies. The Rackham Graduate School publishes the Graduate School Academic Policies with regulations that apply to all graduate students. EE:S graduate students should consult both this Manual and the Rackham Academic Policies.

http://www.rackham.umich.edu/current-students/policies/academic-policies

The EE:S Graduate Program offers six major areas of concentration:
COMMUNICATIONS: Research focuses on system design, optimization, and performance analysis as well as on the development of theory to characterize the fundamental limits of communication system performance, including its mathematical foundations. Areas of specialization include digital modulation, channel coding, source coding, information theory, optical communications, detection and estimation, spread spectrum communication, and multi-user communications and networks.

COMPUTER VISION: Computer vision is the science and technology of giving machines the ability to see, in order to perform real-world visual tasks such as autonomous navigation, visual surveillance, or content-based image and video indexing. Research in computer vision is spread throughout several disciplines in the College of Engineering, including ECE.

CONTROL: Research focuses on fundamental properties of dynamical systems and developing algorithms to modify their behavior through control in order to satisfy performance objectives. Numerous system models are employed, including linear, nonlinear, stochastic, discrete event and queuing models. The faculty work on a wide variety of applications projects, including automotive powertrain control, manufacturing systems, communication networks, robotics, biped locomotion, aerospace, and intelligent transportation systems.

POWER/ENERGY: Research covers power systems and energy processing (power electronics and electromechanical conversion). The focus is on establishing fundamental system properties, and using that knowledge to achieve performance enhancement through systematic design strategies.

ROBOTICS: Robots are evolving from stationary devices that perform manufacturing tasks to mobile, information gathering, computing, and decision-making platforms. We are working on the modeling, estimation and control of multi-robot (multi-agent) systems for applications ranging from intelligent transportation networks to search and rescue. The robotics curriculum is distributed throughout several departments in the College of Engineering, with ECE being a strong participant. Faculty can assist you in selecting courses.

SIGNAL PROCESSING: Research in signal processing deals with the representation, manipulation, and analysis of signals, images, video, and other media. Much of the signal processing research is a collaborative activity within other areas of EECS, particularly in the areas of communication, electromagnetics, artificial intelligence, and biosystems. Furthermore there are active interdisciplinary collaborations with the departments of music, medicine, dentistry, biological sciences, genetics, mechanical engineering, nuclear engineering and radiation sciences, statistics, bio-statistics, and mathematics. Current projects include: image reconstruction, restoration, and segmentation; fast algorithms; tomography and other inverse problems; wavelets and time-frequency distributions; image and video coding; steganography and watermarking; signal detection and target tracking in electro-optical, acoustic and radar remote sensing; pattern recognition and pattern matching; parameter estimation and performance bounds. Applications include: bioinformatics; psychoacoustics; musical instrument sound synthesis and analysis; MIMO communications; packet switched networking; wireless sensor networks; neural measurements and analysis; medical imaging; and surveillance for security applications.

ADMISSION TO THE EE:S GRADUATE PROGRAM

Application for admission to the EE:S Graduate Program is through the Rackham Graduate School. Application is by an online process. http://www.eecs.umich.edu/eecs/graduate/ees/howtoapply.html

It is the responsibility of the applicant to be sure the completed application form is received by the EE:S Program by the specified deadlines. Students admitted to EE:S without a master’s degree will complete the MS/MSE requirements as they progress through the PhD program.

U-M undergraduates in EECS may be eligible to apply for the SGUS program (Sequential Graduate/Undergraduate Study). http://www.eecs.umich.edu/eecs/undergraduate/sgus.html

MASTER’S DEGREE REQUIREMENTS

To receive a master’s degree, a student must satisfy the EE:S Graduate Program requirements outlined below as well as the Rackham School of Graduate Studies General Master's Degree Requirements as stated in the Rackham Graduate School Academic Policies and the College of Engineering Regulations as specified in the College of Engineering Bulletin.

http://www.rackham.umich.edu/current-students/policies/academic-policies

http://www.engin.umich.edu/college/academics/bulletin

www.eecs.umich.edu
There is no separate curriculum for MS and PhD students during the first year of study. At the end of the first year, each student has the opportunity to apply to take the Quals 1 if he/she meets the requirements. Refer to the Quals 1 section of this Manual for further explanation of Quals 1 eligibility requirements.

**Master's Credit hours and Course Distribution**

The MS degree requires a minimum of 30 graduate credit hours with the following distribution:

- **9 credits in a Major**: At least nine (9) credit hours must be earned from the kernel of a major area (Control, Communications, Signal Processing), including at least six (6) at the 500 level or higher. (Power/Energy & Computer Vision majors should meet with the area academic advisor regarding course selection.)

- **6 credits in a Minor**: At least six (6) credit hours must be earned from the kernel of a minor area, including at least three (3) at the 500 level or higher. No course may be counted toward both the major and minor requirements, except in the following situation. If a course is a requirement or a member of a group requirement in both the major and minor kernels, then it may be used to satisfy the requirement and/or group requirement of both kernels. However, an additional course shall be taken from one of the kernels.

If the minor is outside EE:S, any credits in excess of 6 may be counted toward the cognate requirement.

- **4 credits of a Cognate**: Students are expected to satisfy the Rackham cognate requirement, which states that students must complete at least 4 hours of graduate-level coursework in a field or fields other than the student’s field of specialization. Courses taken to satisfy the cognate requirement must be approved for Rackham graduate credit and by the student’s advisor. EE:S requires cognate courses be graded (not Satisfactory/Unsatisfactory). Final grade must be B- or better. Any courses associated with EE:S cannot be used to satisfy the cognate requirement. Cognate must be in addition to any classes taken in major/minor.

A maximum of four (4) credit hours of Research, Directed Study and/or Seminar (any S-graded courses) may be counted toward the degree.

- At least twenty-four (24) credits must be earned in (graded) technical courses. The guidelines for a technical graded class are:
  - The course must be graded (A/B/C), not Satisfactory/Unsatisfactory.
  - All graded courses from CoE, Math, Physics, Chemistry…(Science in general) are accepted.
  - Courses from Economics, Business, etc., will be judged on an individual basis by the student and his/her academic advisor.
  - The final Plan of Study must be approved by the academic advisor.

- At least twelve (12) credits must be earned in EECS course work at the 500 level or higher. Credits earned in other departments or universities and credit hours earned in individual study, research or seminar courses cannot be counted toward this requirement.

*Math 404, 417, 425, 448, 450 and their cross-listed courses may not be counted for any degree requirements. Rack 998 (Curricular Practical Training) may not be counted for any degree requirements.*

**Major and Minor Areas**

The EE:S Master’s Program requires the completion of a minimum of 3 kernel classes in a major and 2 kernel classes in a minor. **Not all courses within a given area of study are designated as kernel courses.** Refer to the EE:S Kernel Course section of this Manual for a list of the classes in each area of study.

EE:S students must select the **MAJOR** area of study from:
- Communications
- Control Systems (includes Power/Energy and Robotics)
- Signal Processing (includes Computer Vision)

The **MINOR** area must be different from the major and must be chosen from (i) the list above, (ii) the following:
- Biosystems
- Manufacturing
- Circuits and Microsystems
- Computers
- Applied Electromagnetics and RF Circuits
- Optics and Photonics
Solid State

OR (iii) an outside area of concentration. A student desiring the latter must submit a petition outlining a proposed set of courses sufficiently distinct from the major and which constitutes a cohesive curricular concentration. This petition should be presented before the student starts taking the courses.

*Students entering graduate school often have interests that span two or more of the three “major” areas in Systems: Communications, Control, and Signal Processing. Moreover, there are areas of research that overlap with more than one of the three above areas. If a student has difficulty choosing a major area, he/she should meet with the EE:S Graduate Chair prior to starting the first semester of graduate studies. The kernel requirements have a certain amount of flexibility allowing a student with the approval of the EE:S Graduate Chair to design a plan of study that is consistent with: (i) the student's interests and (ii) the EE:S program goal of ensuring that each student achieve depth in a sub-area of EE:S. The Graduate Chair will assign an appropriate academic advisor for the student in this situation.*

**Master's Plan of Study**

At the beginning of the first term of enrollment, each student will meet with an academic advisor to outline a Plan of Study based on the student's interests. The Plan of Study will contain the courses the student intends to take to satisfy the degree requirements. The Plan of Study may then be modified as the student progresses through the program.

*It is the responsibility of the student to submit to the EE:S Graduate Coordinator an updated, signed final Plan of Study using the select when applying for conferral of the MS degree.*

[http://www.eecs.umich.edu/eecs/graduate/ees/Web_MS_Plan_Study.pdf](http://www.eecs.umich.edu/eecs/graduate/ees/Web_MS_Plan_Study.pdf)

[http://www.eecs.umich.edu/eecs/graduate/ees/Web_Course_list_MS_PhD.pdf](http://www.eecs.umich.edu/eecs/graduate/ees/Web_Course_list_MS_PhD.pdf)

**Master's Thesis Option**

The option of writing a Master’s thesis is available to Master’s students in good academic standing. A student wishing to exercise this option may initiate the process through three steps: (i) find an EECS faculty member willing to serve as the Thesis Advisor, (ii) enroll in the Master’s thesis course for one to six credit hours, and (iii) arrange for a Master’s Thesis Committee to be approved by the EE:S Graduate Chair.

The Thesis Advisor is responsible for supervising the work of the Master’s thesis project. The Master’s Thesis Committee will consist of the Thesis Advisor, as chair, and two additional faculty members. The committee members will be available for consultation and will evaluate the thesis.

The student must satisfactorily complete the Master’s thesis course for a maximum of six (6) credit hours. These credit hours may be spread over more than one term. The course may be taken for one to six credit hours per term and shall be graded on an S/U basis.

The student must write a report that is substantially consistent with the Rackham format for theses. Each member of the Master’s Thesis Committee must submit a written evaluation of the thesis. Approval of the thesis by all committee members is required. In addition to the thesis, the Master’s Thesis Committee may request an oral report.

The student must elect the thesis option within thirteen months of first enrolling in the Master’s program. The thesis must be completed within twelve (12) months of the initial election of the thesis course.

**Applying for the MS Degree**

Conferral of the MS degree is not automatic. A student who has completed the MS degree requirements must submit a signed, completed MS Plan of Study to the EE:S Graduate Coordinator and submit an application for degree to the Rackham Graduate School via the Wolverine Access System.
Grading Policy

1. All grades are on the Rackham Graduate School scale:

   
<table>
<thead>
<tr>
<th>Grade</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>4.3</td>
</tr>
<tr>
<td>A</td>
<td>4.0</td>
</tr>
<tr>
<td>A-</td>
<td>3.7</td>
</tr>
<tr>
<td>B+</td>
<td>3.3</td>
</tr>
<tr>
<td>B</td>
<td>3.0</td>
</tr>
<tr>
<td>B-</td>
<td>2.7</td>
</tr>
<tr>
<td>C+</td>
<td>2.3</td>
</tr>
<tr>
<td>C</td>
<td>2.0</td>
</tr>
<tr>
<td>C-</td>
<td>1.7</td>
</tr>
<tr>
<td>D+</td>
<td>1.3</td>
</tr>
<tr>
<td>D</td>
<td>1.0</td>
</tr>
<tr>
<td>D-</td>
<td>0.7</td>
</tr>
</tbody>
</table>

2. EE:S requires a course grade must be B- or better for the credit hours to be counted toward any degree requirement (including the 30 total credit hours.)

3. The grade point average (GPA) must be at least 3.0, based on Rackham’s 4.0 scale. Rackham rules require a student maintain satisfactory academic standing; a student must have a minimum cumulative GPA of 3.0 (B) to be granted a degree. **NOTE**: EE:S requires all course grades be B- or above to be counted toward degree requirements.

Equivalency

If a student has taken a course elsewhere that is “substantially equivalent” to a course in the Major or Minor kernels, it is not necessary to retake the course provided that the student is awarded equivalency for the course. The student should consult with his/her adviser at the earliest opportunity to determine whether equivalency is appropriate and to make a formal application for equivalency. Note that equivalency is only required for courses that are to be substituted for kernel courses.

*The Quals 1 exam will cover kernel courses deemed equivalent. It is the student’s responsibility to be sure he/she understands the course material as it is taught in the EE:S Graduate Program.*

Policy for Dropping Courses

After the eighth week of a full term (fourth week of a half term), courses may be dropped or changed to Visit status only under exceptional circumstances and with the approval of the course instructor, advisor, and the graduate chair of the program. The specific deadline dates are posted in the EE:S Graduate Offices and on the EE:S Program website. The Rackham Graduate School rules for dropping courses also apply (see the Rackham Student Handbook.).

Transfer of Credit

Students wishing to transfer credit must follow the Rackham transfer of credit guidelines. Students may not request transfer of credit until completion of a minimum of 8 graded graduate level credits and have a minimum GPA of 3.0.

[http://www.rackham.umich.edu/help/academic_records/transfer_of_credit_information/](http://www.rackham.umich.edu/help/academic_records/transfer_of_credit_information/)

Petition for Waiver or Modification of Policy or Requirement

A student requesting a change of policy or requirement must seek the advice of the academic or research advisor and then submit a petition to the EE:S Graduate Committee.

[http://www.eecs.umich.edu/eecs/graduate/ees/Web_Petition_Request.pdf](http://www.eecs.umich.edu/eecs/graduate/ees/Web_Petition_Request.pdf)

Honor Code

All engineering programs at the University of Michigan follow the College of Engineering Honor Code outlining certain standards of ethical conduct. Reported violations of the Honor Code are investigated by the Honor Council.

[http://www.engin.umich.edu/students/honorcode/index.html](http://www.engin.umich.edu/students/honorcode/index.html)

English Proficiency

Based on English language proficiency test scores (such as the TOEFL), some students will be encouraged by the Rackham Graduate School to take specific academic writing or speaking courses offered by the English Language Institute (ELI) to support their studies. The ELI courses are typically 1 to 3 credits, and will help students gain capability and confidence in English. These courses will not count toward the degree or GPA.
A student’s English proficiency is also evaluated as the student participates in the oral Qualifying Exams and Research Thesis Proposal presentation. If the faculty consider the student to otherwise be qualified for the EE:S PhD program, it may be recommended the student take English courses. Students with major deficiencies in English will be found Not Qualified for the EE:S PhD Program.

Curricular Practical Training (CPT) for F-1 Students

Students wishing to enroll in Curricular Practical Training (CPT) must complete all necessary paperwork required by the International Center. The student must consult with the academic advisor and receive final written approval. Credit for CPT (Rack 998) may not be counted toward any EE:S degree requirements.

Financial Aid

EE:S students may be funded in the form of fellowships, Graduate Student Instructor (GSI) positions, and Graduate Student Research Assistant (GSRA) positions. Students seeking GSRA positions must contact faculty directly. The EE:S program is not able to fund every graduate student and therefore, encourages students to apply for outside fellowships.

http://www.eecs.umich.edu/eecs/graduate/EECSFinAid/ECEFinaid.html

Transition from EE:S Master’s to EE:S PhD

Students interested in changing status from EE:S MS to EE:S PhD prior to completion of the MS degree requirements, must follow the steps below:

- Follow the rules and timetable for the PhD qualification exam: take 4 courses approved for the Qual 1 exam during the first and second terms of enrollment.

- Initiate a research relationship with an EECS faculty member.

- Submit a Qual 1 application for the May, September, or January exam which is signed by the faculty member with whom research has either begun or is about to begin. This application must be signed by the EECS faculty member who is advising the student and offering financial support.

- Take and pass the Qual 1 exam.

- Complete the Rackham application for PhD. (Note: letters of recommendation, statement of purpose, etc. are not required since they are on record from the MS application.)

Financial support in the form of a research assistantship from a faculty member is necessary (but not sufficient) for transitioning from MS to PhD.

Students interested in changing status from EE:S MS to EE:S PhD after completion of the MS degree requirements, must follow the same procedure as non-U-M applicants by completing the Rackham Graduate School online application for PhD admission the term after completion of the MS degree.

DOCTORAL DEGREE REQUIREMENTS

The doctoral degree (PhD) is conferred in recognition of marked ability and scholarship in a broad field of knowledge and the demonstrated ability to carry out independent research yielding significant original results. The Doctoral Program proceeds in three stages: (i) qualification, (ii) achieving candidacy, and (iii) writing and defending the dissertation.
To receive a PhD degree, a student must satisfy the EE:S Graduate Program requirements outlined below as well as the Rackham School of Graduate Studies General Master’s Degree Requirements as stated in the Rackham Graduate School Academic Policies and the College of Engineering Regulations as specified in the College of Engineering Bulletin.

http://www.rackham.umich.edu/current-students/policies/academic-policies
http://www.engin.umich.edu/college/academics/bulletin

Rackham doctoral degree steps: http://www.rackham.umich.edu/current-students/policies/doctoral/phd-students/doctoral-steps

PhD Credit hours and Course Distribution

The PhD degree requires a minimum of **36 graduate credit hours** with the following distribution:

1. **Major:** At least six (6) courses must be earned from the kernel of a major area (Control, Communications, Signal Processing). (Power/Energy & Computer Vision majors should meet with the area academic advisor regarding course selection.)

2. **Minor:** At least three (3) courses must be earned from the kernel of a minor area. No course may be counted toward both the major and minor requirements, except in the following situation. If a course is a requirement or a member of a group requirement in both the major and minor kernels, then it may be used to satisfy the requirement and/or group requirement of both kernels. However, an additional course shall be taken from one of the kernels. If the minor is outside EE:S, any credits in excess of minor requirements may be counted as cognate.

3. **4 credits of a Cognate:** Students are expected to satisfy the Rackham cognate requirement, which states that students must complete at least 4 hours of graduate-level coursework in a field or fields other than the student’s field of specialization. Courses taken to satisfy the cognate requirement must be approved for Rackham graduate credit and by the student’s advisor. EE:S requires cognate courses be graded (not Satisfactory/Unsatisfactory). Final grade must be a B- or better. Courses associated with EE:S cannot be used to satisfy the cognate requirement. Cognate must be in addition to any classes taken in major/minor.

4. A maximum of four (4) credit hours of Research, Directed Study and/or Seminar (any S-graded courses) may be counted toward the degree.

5. **At least twenty-four (24) credits must be earned in (graded) technical courses.** The guidelines for a technical graded class are:
   - The course must be graded (A/B/C), not Satisfactory/Unsatisfactory.
   - All graded courses from CoE, Math, Physics, Chemistry...(Science in general) are accepted.
   - Courses from Economics, Business, etc., will be judged on an individual basis by the student and his/her academic advisor
   - The final Plan of Study must be approved by the academic advisor.

6. **At least twelve (12) credits must be earned in EECS course work at the 500 level or higher.** Credits earned in other departments or universities and credit hours earned in individual study, research or seminar courses cannot be counted toward this requirement.

*Math 404, 417, 425, 448, 450 and their cross-listed courses may not be counted for any degree requirements. Rack 998 (Curricular Practical Training) may not be counted for any degree requirements.*

Major and Minor Areas

Same as for the Master’s degree (above).

PhD Plan of Study

The PhD Plan of Study should be completed with the assistance of an academic advisor to be certain academic requirements for Candidacy are met.

http://www.eecs.umich.edu/eecs/graduate/ees/Web_PhD_Plan_Study.pdf
http://www.eecs.umich.edu/eecs/graduate/ees/Web_Course_list_MS_PhD.pdf

Relevant Master’s
If a student entering the EE:S program already has a MS degree, it is determined at the time of admission if the MS degree course work is very similar to the EE:S MS degree requirements/course work. If the course work is very similar, it is deemed to be relevant. The student is then granted 18 credit hours toward the PhD. The student must still meet the EE:S candidacy course requirements, either through equivalency or by taking the required coursework.

A student with a Relevant MS degree cannot earn a MS degree in EE:Systems. Failing a Qualifying Exam with a Relevant MS degree means the student must terminate PhD study in EE:S and leave the EE:S Program without receiving any degree.

**PhD QUALIFICATION**

Qualification for the PhD degree occurs in two stages: Quals 1 and Quals 2.

The Quals 1 exam is taken in or shortly after the first year of study. After passing Quals 1, the student works on research in the form of a Research-Oriented Directed Study or Master's thesis to prepare for the Quals 2 exam. The Quals 2 exam is taken by the end of the second year and examines the student's research capabilities. After successfully passing Quals 2, the student proceeds to Candidacy and the presentation of the Research Thesis Proposal and ultimately the final defense of the Dissertation.

**QUALS 1**

Quals 1 is an oral examination to evaluate the student’s basic knowledge in the field as well as his/her ability to interrelate various topics and concepts, analyze problems, and synthesize solutions.

Questions are based on material from the Doctoral Qualifying Course Work taken in the first year and are typically application of knowledge rather than memorization of information.

Qualification Course Work:

As part of the qualifying process, a student must complete a set of courses known collectively as the Doctoral Qualification Course Work. This course work is a subset of the Doctoral Course Work required for Candidacy and consists of a total of 4 kernel courses that can be divided either as:

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 courses in Major</td>
<td>4 courses in Major</td>
</tr>
<tr>
<td>1 course in EE:S Minor (See note below)</td>
<td>no Minor courses</td>
</tr>
</tbody>
</table>

Note: The 4 courses selected for the Qualifying I exam must be EE:S courses, unless a petition is filed and approved. If the student is pursuing a minor in an area of study outside EE:S, he/she must be examined on 4 EE:S courses in the major area of study (Option 2).

Grades are an important factor taken into consideration for the Quals exams. While no threshold has been set, statistics show that students who become candidates generally have an average GPA of at least an 3.7 (A-).

http://www.eecs.umich.edu/eecs/graduate/ees/Web_Course_list_MS_PhD.pdf

Quals 1 Background Information:

Beyond the material taken in kernel courses, the student is expected to have a basic understanding of undergraduate material from the major area:

<table>
<thead>
<tr>
<th>Area</th>
<th>Relevant Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>EECS 455</td>
</tr>
<tr>
<td>Control</td>
<td>EECS 460</td>
</tr>
<tr>
<td>Signal Processing</td>
<td>EECS 451</td>
</tr>
</tbody>
</table>

Scheduling of Quals 1 Exam:

Qualifying exams are offered during a three week period, near the beginning of the Fall, Winter and Spring terms. At least six weeks prior to the exam, the student must submit a Quals Exam Application.

To be eligible to take the Quals 1 exam, at the time of qual exam application, a student must have taken the necessary coursework and be making satisfactory academic progress based on performance in the course work taken during the first academic year, the
overall academic record, and English proficiency. The student must be engaged in research with a faculty member who is eligible to supervise EE:S students, or have identified such a faculty member with whom he/she will begin to do research.

Examiners:

A Quals Exam Committee consisting of three faculty members appointed by the EE:S Graduate Committee administers the exam. The faculty members are selected based on the student's Doctoral Qualification Course Work. Following the exam, each member of the Examining Committee will submit an evaluation of the student's performance to the EE:S Faculty.

Quals 1 Decision:

The decision to approve a student for continued doctoral study is made by the EE:S Faculty, which meets at the end of each Qual exam period. The decision is based on performance in the course work taken during the first academic year, the performance during the Qual 1 Exam, the overall academic record, and English proficiency.

Possible decisions are:

1. Approved for continued doctoral study (Students with minor deficiencies in English proficiency may be required to satisfactorily complete certain English language courses).
2. Not approved for continued doctoral study, but allowed to retake Part 1 of the Qualifying Examination.
3. Not approved for continued doctoral study, and not permitted to retake Part 1 of the Qualifying Examination.

A MS student who passes Quals 1 may apply for the EE:S PhD program via the Rackham application website. The decision to accept will be based on the student's performance in coursework and research, as well as the commitment of his/her advisor to work with and support the student. Such an application must be made within 15 months of entry into the EE:S MS program. A student who is admitted to the PhD program will be guaranteed financial support until five years from the date of his/her entry into the EE:S MS program, provided satisfactory progress continues to be made.

Quals 1 Timing:

All students entering the EE:S Graduate Program are encouraged to take Quals 1 within 9 month of entry and must be approved for continued study in the doctoral program within 15 months.

Each student has a maximum of two opportunities to take the examination.

Research-Oriented Directed Study

Upon passing Quals 1 (if not before), a student will begin work on the Research-Oriented Directed Study under the supervision of his/her Research Advisor, who, in general, is a member of the EE:S Faculty. It should include background study in the selected topic area and the beginning of original research. The student should write a concise report summarizing this work. This report is due at the time of application for Quals Exam Part 2.

The amount of research required is commensurate with a three hour directed study for two semesters (6 hours total). An oral presentation of the work is included in the Quals 2 exam. In addition, the research advisor writes an evaluation of the student's work and research capabilities. The student may register for Research Work in EECS 599 or 699 while pursuing the Research Oriented Directed Study. However, this is not required to take Quals 2.

In many cases the topic of the Research-Oriented Directed Study develops into a dissertation topic and the research advisor becomes the Dissertation Advisor. Accordingly the student should choose the topic and research advisor with care.

QUALS 2

Quals 2 is an oral exam intended to examine the student's research capabilities. The student will make a short presentation (30 minutes or less) describing the area of research investigated during the Research-Oriented Directed Study and will be questioned by a three-member examining committee. The student must demonstrate an understanding of his/her chosen research area. In addition, some preliminary results (positive or negative) must be obtained.

Scheduling of Quals 2 Exam:

Qualifying exams are offered during a three week period, near the beginning of the Fall (Sept.), Winter (Jan.) and Spring (May) terms. The student must submit a Quals 2 Exam Application and submit a written report of the Research-Oriented Directed Study to the examining committee.

Examiners:
A Quals Exam Committee consisting of three faculty members appointed by the EE:S Graduate Committee administers the exam. The exam committee is selected to reflect the student’s technical areas of research. None of the examiners will be the Research Advisor.

Quals 2 Decision:

The decision to qualify for the doctoral program is made by the EE:S faculty, which meets at the end of each Qual exam period. The decision is based on the Research-Oriented Directed Study, the Quals 2 exam, doctoral course work, the overall academic record, and English proficiency (both written and oral).

Possible decisions are:

1. Qualified for the Doctoral Program (Students with minor deficiencies in English proficiency may be required to satisfactorily complete certain English language courses.)
2. Not qualified for the Doctoral Program but allowed to retake Part 2 of the qualifying examination.
3. Not qualified for the Doctoral Program.

Quals 2 Timing:

Students entering with a Bachelor’s Degree must pass Quals 2 and qualify for the Doctoral program within 25 months of entry but are strongly encouraged to take the exam within 21 months. Students entering with a relevant Master’s Degree must pass Quals 2 and qualify for the Doctoral program within 21 months of entry but are strongly encouraged to take the exam within 18 months.

Each student has a maximum of two opportunities to demonstrate research ability through the Quals 2 exam.

PhD CANDIDACY

Candidacy signifies that all PhD requirements with the exception of writing and defending the dissertation have been completed. A topic is selected for the dissertation; a Research Thesis Proposal is presented to the Dissertation Committee of which the Chair is the Research Advisor; and subsequent successful writing and defending of the doctoral dissertation fulfill the requirements for the PhD degree.

Candidacy Requirements

1. Completed 36 credit hours as described in the PhD Credit Hours and Course Distribution section.
2. Passed Quals 2 exam.
3. Satisfied all Rackham candidacy requirements.

http://www.rackham.umich.edu/current-students/policies/academic-policies/section5#51

Completing the course work required for candidacy normally takes place parallel to the Research-Oriented Directed Study. Rackham expects students to achieve candidacy no later than three calendar years after the first enrollment in their doctoral program. A student who does not achieve candidacy within three years will be placed on academic probation, unless the graduate program petitions Rackham to request additional time because of extenuating circumstances.

Candidacy is not automatic; once all EE:S and Rackham requirements are met, a student must apply for candidacy by submitting the appropriate forms.

Candidacy Course Enrollment

Once a student has attained Candidacy status, he/she will enroll in 8 credits of EECS 995 each term. Tuition reduces to the Candidacy rate.

In addition to EECS 995, candidates may elect one course per term without paying tuition beyond candidacy tuition. This course may be taken for credit or as a visit (audit). A student who does not elect a course during a term of 995 enrollment may elect two courses in the next term of 995 enrollment; no more than one course may be deferred in this manner (an additional course may not be taken in anticipation of taking none in a future term of 995 enrollment). Candidates who choose to take more courses than those for which they are eligible with candidacy tuition will be assessed additional tuition per credit hour.

It is the student’s responsibility to cover the tuition costs for any courses taken in addition to the free course described above, even if the student is being funded through a fellowship, GSI or GSRA position.
RESEARCH THESIS PROPOSAL PRESENTATION

After passing Quals 2, a student typically continues to work with his/her Research Advisor who becomes the Dissertation Chair. (A student may also have a co-chair.) The Dissertation Chair(s) play the primary role in guiding the student toward completion of the PhD. The chair(s) also assist the student in forming the Dissertation Committee.

After a period of further research, the student will write a concise Research Thesis Proposal and give a formal oral presentation of the work to the Dissertation Committee. The written Thesis Proposal must be submitted to the committee at least two weeks in advance of the oral presentation.

During the Thesis Proposal Presentation, the student should:

1. Precisely identify and describe the area of research.
2. Demonstrate an in-depth understanding of the area including mastery of the literature on the subject area.
3. Give a general description of the research problem to be addressed.
4. Provide an outline of the methodology to be taken.

During and after the Research Thesis Proposal Presentation, the Committee will explore the proposed research with the student in order to provide guidance and make and evaluation if its suitability. The Committee will determine if the student has or does not have an acceptable proposal.

Failure to have an acceptable proposal requires revising the proposal and scheduling another formal presentation to the Committee. If the proposal is not acceptable, the student has 12 months to prepare and present a satisfactory proposal.

Timing of Research Thesis Proposal Presentation

Students entering the Doctoral Program with a Bachelor's degree must write and orally present the Research Thesis Proposal within 36 months of entry to the program. Students entering the Doctoral program with a Relevant Master's degree must present within 30 months.

PhD Progress and Financial Support

As stated in the offer letter, continued enrollment and guaranteed financial support is contingent upon satisfactory academic and research progress on the part of the student in his/her academic program.

(i) The student will be periodically informed about his/her academic performance.

Yearly student evaluations will be conducted in April, with a due date of April 30. The student and his/her research advisor will complete and sign the progress report. This report will identify one of three outcomes regarding the student’s overall academic and research progress: “Satisfactory”; “Concerns”; “Unsatisfactory”. Submission of this report is mandatory.

The Graduate Chair may request a student to submit a progress report prior to the April yearly evaluation.

(ii) When the student's progress is deemed not satisfactory (“Concerns” or “Unsatisfactory”), updated progress reports will have to be submitted, as required by the program’s Graduate Chair; at these times, the student’s overall progress will be re-evaluated.

(iii) Lack of submission of a progress report or of an updated progress report will automatically lead to an “Unsatisfactory” rating.

(iv) Lack of satisfactory progress may lead to the termination of the guarantee of financial support and to the discontinuation from the graduate program.

(v) A student with guaranteed financial support will be told in writing at least two months before his/her stipend actually ends. If the stipend is terminated during a term in which the student is enrolled, outstanding financial obligations including tuition, associated fees, and benefits will be covered until the end of the given term.
**DISSERTATION DEFENSE**

**Dissertation Committee**

In collaboration with the Dissertation Chair(s), the student forms a Dissertation Committee following specific guidelines regarding the composition of the Committee.

Among these rules are the following for students in the EE:S PhD Program:

1. The committee must consist of four or more members; at least two of the members must be affiliated with the EE:S program.

2. The Research Advisor (or Co-Advisors) will serve as Chair (or Co-Chairs) of the committee. The Chair, or at least one of the Co-Chairs, must be from the EECS Department. EE:S, EE and CSE faculty may serve as chairs on any committee.

3. In accordance with Rackham rules, one of the Committee members is designated as "cognate member." The cognate member must be from outside ECE (EE:S and EE). CSE faculty may serve as cognates.

For detailed dissertation committee formation guidelines, refer to the Rackham website.

http://www.rackham.umich.edu/dissertation_information/

**Dissertation Progress Reviews**

Once the student has successfully presented the Research Thesis Proposal, he/she should meet informally (or formally, at the discretion of the Dissertation Chair). The student should meet with the Dissertation Committee at least once per year. During these meetings the committee will determine if the student is making satisfactory progress toward finishing the dissertation. The committee, at the request of the Dissertation Chair, will report to the ECE Graduate Committee if the student is not making satisfactory progress. After two consecutive unsatisfactory progress reports the ECE Graduate Committee may terminate the enrollment of the student in the EE:S doctoral program.

**Dissertation Final Defense**

Each PhD Candidate must prepare a dissertation, giving evidence of his/her ability to conduct original, advanced research and to present the results of that research in well-written form. The student must also defend the work orally in an open examination called the Final Defense.

A final and complete copy of the written dissertation must be given to each member of the Dissertation Committee at least 17 business days before the scheduled date of the Final Defense to allow sufficient time for a written evaluation. The Final Defense will only be held if the dissertation is deemed acceptable by the Dissertation Committee. Once all members of the Dissertation Committee find the dissertation acceptable, the Final Defense is held.

In most cases, the student will be required to make some minor revisions to the dissertation based on the Committee comments during the Final Defense. Once all corrections are made, the Committee recommends to Rackham conferral of the PhD degree.

Rackham provides detailed information and steps for completing the PhD degree process:

http://www.rackham.umich.edu/current-students/policies/doctoral/phd-students/doctoral-steps

**Final Defense Timing**

The student must be enrolled in 8 hours of EECS 995 the term of the Final Defense. The student must defend and complete all Rackham degree requirements before the final doctoral degree deadline for the term.

http://www.rackham.umich.edu/current-students/policies/doctoral/phd-students/doctoral-degree-deadlines
**MS & PhD TIMELINES/DEADLINES**

The timelines below display a "typical" three-semester MS and 10-semester PhD program for a student entering the graduate program with a Bachelor's degree.

Students must complete all work for the MS degree within five years from the date of first enrollment in the program. Those exceeding this limit must petition Rackham for a time extension or be withdrawn from the program.

**MS Degree Timeline**

<table>
<thead>
<tr>
<th>Academic Term</th>
<th>Curricular Activities</th>
<th>Research Activities</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1: Fall</td>
<td>3 courses</td>
<td>Departmental and area research seminars, Faculty/student research meetings</td>
<td>GPA</td>
</tr>
<tr>
<td>Year 1: Winter</td>
<td>3-4 courses</td>
<td>departmental and area research seminars, faculty/student research meetings, optional: choose advisor for MS thesis</td>
<td>GPA</td>
</tr>
<tr>
<td>Year 1: Sp/Su</td>
<td>(optional: MS thesis research)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 2: Fall</td>
<td>3-4 courses, (optional: MS research studies)</td>
<td>departmental and area research seminars, faculty/student research meetings, optional: complete MS thesis research</td>
<td>GPA</td>
</tr>
<tr>
<td>Year 2: Winter</td>
<td>Optional semester of coursework</td>
<td></td>
<td>Apply for MS Degree</td>
</tr>
</tbody>
</table>
PhD Degree Timeline

Below is the typical timeline for the PhD student. Because of the nature of the research and degree itself, the PhD is unique to each student and is subject to greater leeway in timing. Nevertheless, the EE:S Program expects the majority of students to complete the PhD degree within five years. Students who take longer than 5 years to complete the PhD degree may lose departmental financial aid. Rackham’s time to degree is 7 years from first enrollment in the program. Students not completing the degree in 7 years must submit a petition to Rackham requesting an extension.

<table>
<thead>
<tr>
<th>Academic Term</th>
<th>Curricular Activities</th>
<th>Research Activities</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1: Fall</td>
<td>3 courses</td>
<td>departmental and area research seminars, faculty/student research meetings</td>
<td>GPA</td>
</tr>
<tr>
<td>Year 1: Winter</td>
<td>3-4 courses, prepare for the Quals 1</td>
<td>departmental and area research seminars, faculty/student research meetings</td>
<td>GPA, pass Quals 1, identify a research advisor for Quals 2</td>
</tr>
<tr>
<td>Year 1: Sp/Su</td>
<td></td>
<td></td>
<td>identify a topic for Quals 2 research project, begin preliminary readings and a preliminary problem statement</td>
</tr>
<tr>
<td>Year 2: Fall</td>
<td>2-3 courses directed research</td>
<td>faculty/student research meetings in area of interest, directed research with research advisor</td>
<td>GPA, refine the problem statement and begin research, complete MS degree requirements and apply for MS degree</td>
</tr>
<tr>
<td>Year 2: Winter</td>
<td>2-3 courses + directed research, prepare for Quals 2 exam</td>
<td></td>
<td>GPA, complete research, write up results as a report for the Quals 2 exam committee, successfully defend research in the Quals 2 exam and become a PhD candidate when course requirements are satisfied</td>
</tr>
<tr>
<td>Year 2: Sp/Su</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 3: Fall</td>
<td>2-3 courses to complete PhD course requirements or 1 course (max) + EECS 995, if already a candidate</td>
<td>research with research advisor, faculty/student research meetings in other areas of interest</td>
<td>problem formulation, preliminary readings and derivations for PhD Thesis Proposal</td>
</tr>
<tr>
<td>Year 3: Winter</td>
<td>1 course (max) + EECS 995</td>
<td>research with research advisor, faculty/student research meetings in other areas of interest</td>
<td>problem statement, refinement, form dissertation committee and present a Thesis Proposal</td>
</tr>
<tr>
<td>Year 3: Sp/Su</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 4: Fall</td>
<td>1 course (max) + EECS 995</td>
<td>PhD research</td>
<td>Update dissertation committee on research progress (at least once during the academic year)</td>
</tr>
<tr>
<td>Year 4: Winter</td>
<td>1 course (max) + EECS 995</td>
<td>Ph.D. research</td>
<td>Update dissertation committee on research progress (at least once during the academic year)</td>
</tr>
<tr>
<td>Year 4: Sp/Su</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 5: Fall</td>
<td>1 course (max) + EECS 995</td>
<td>Ph.D. research</td>
<td>Update dissertation committee on research progress (at least once during the academic year)</td>
</tr>
<tr>
<td>Year 5: Winter</td>
<td>1 course (max) + EECS 995</td>
<td>Ph.D. research</td>
<td>Final defense of dissertation before dissertation committee, complete any dissertation revisions, graduate with PhD</td>
</tr>
<tr>
<td>Year 5: Sp/Su</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PhD Degree Deadlines

Experience has shown that successful doctoral students devote a majority of their time to their academic program. Consequently, these deadlines apply to all EE:S students, including those with GSI (Graduate Student Instructor) or RA (Research Assistant) appointments, as well as those carrying outside obligations.
Any departure from the timetable must be explicitly requested by written petition. The EE:S Graduate Committee will review each petition, and each decision will be made on the individual merits of the petition. The Graduate Committee may terminate the enrollment of any student who fails to follow these procedures.

Students entering the EE:S Graduate Program with a Bachelor’s degree:

1. Successfully complete Part 1 of the Qualifying Examination for the Doctoral Program within 13 months of entry
2. Successfully complete Part 2 of the Qualifying Examination for the Doctoral Program within 25 months of entry (such students are strongly encouraged to take Part II within 21 months)
3. Achieve Candidacy within 36 months of entry
4. Present a research proposal to a dissertation committee within 36 months of entry
5. Complete the dissertation within six years of entry. (Ordinarily the entire PhD program should take no more than five years to complete.)

Students entering the Graduate Program with a relevant Master’s degree:

1. Successfully complete Part 1 of the Qualifying Exam for the Doctoral Program within 13 months of entry
2. Successfully complete Part 2 of the Qualifying Examination for the Doctoral Program within 21 months of entry (such students are strongly encouraged to take Part II within 18 months)
3. Achieve Candidacy within 30 months of entry
4. Present a research proposal to a dissertation committee within 30 months of entry
5. Complete the dissertation within five years of entry. (Usually the entire Ph.D. program should take no more than four years to complete.)

**EE:S MS/PhD Course Requirements by MAJOR:**

http://www.eecs.umich.edu/eecs/graduate/ees/Web_Course_list_MS_PhD.pdf

**EECS Course Descriptions:**

http://www.engin.umich.edu/students/bulletin/eecs/courses.html
EE:S KERNEL COURSES:

CONTROL

Major
For MS Degree: Three courses from the following list: EECS 460, 461, 501, 558, 560, 561, 562, 564, 565, 566, 567, 662, NAME 531.

For PhD QUALIFICATION: EECS 560; two from EECS 501, 558, 562, 565.

For CANDIDACY: Three courses beyond the qualification coursework from EECS 501, 502, 558, 561, 562, 564, 565, 566, 567, 600, 662, Math 451, NAME 531, except that a student may not count both 600 and Math 451.

Alternatively, the student may elect other courses having significant control content and/or relevant to the student's area of research. Permission to take such courses must be obtained from the EE:S Graduate Chair based upon the recommendation of the student's academic advisor.

Minor
For MS Degree: Two courses from the following list: EECS 460, 461, 501, 558, 560, 561, 562, 564, 565, 566, 567, 662.

For PhD QUALIFICATION: any one from 460, 558, 560

For CANDIDACY: Three courses from the following list: EECS 460, 501, 558, 560, 561, 562, 564, 565, 566, 567, 662, NAME 531.

Control Course Titles

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECS 460</td>
<td>Control Systems Analysis and Design</td>
</tr>
<tr>
<td>EECS 461</td>
<td>Embedded Control Systems</td>
</tr>
<tr>
<td>EECS 501</td>
<td>Probability and Random Processes</td>
</tr>
<tr>
<td>EECS 502</td>
<td>Stochastic Processes</td>
</tr>
<tr>
<td>EECS 558</td>
<td>Stochastic Control</td>
</tr>
<tr>
<td>EECS 560</td>
<td>Linear Systems Theory</td>
</tr>
<tr>
<td>EECS 561</td>
<td>Design of Digital Control Systems</td>
</tr>
<tr>
<td>EECS 562</td>
<td>Nonlinear Systems and Control</td>
</tr>
<tr>
<td>EECS 564</td>
<td>Estimation, Filtering and Detection</td>
</tr>
<tr>
<td>EECS 565</td>
<td>Linear Feedback Control Systems</td>
</tr>
<tr>
<td>EECS 566</td>
<td>Discrete Event Systems</td>
</tr>
<tr>
<td>EECS 567</td>
<td>Introduction to Robotics: Theory and Practice</td>
</tr>
<tr>
<td>EECS 600</td>
<td>Function Space Methods in System Theory</td>
</tr>
<tr>
<td>EECS 662</td>
<td>Advanced Nonlinear Control</td>
</tr>
<tr>
<td>Math 451</td>
<td>Advanced Calculus I</td>
</tr>
</tbody>
</table>
COMMUNICATIONS

Major
For MS Degree: EECS 501; plus two of the following: EECS 455, 502, 550, 553, 554, 555, 557, 564, 650, except that the following pair is not allowed: (455,554).
For PhD QUALIFICATION: EECS 501, EECS 554; and one from: EECS 502, 550, 553, 555, 557, 650.
For CANDIDACY: EECS 501, EECS 554, EECS 600 or Math 451; and three more from the following: EECS 502, 550, 553, 555, 557, 564, 650.
Alternatively, the student may elect other courses having significant communications content and/or relevant to the student's area of research. Permission to take such courses must be obtained from the EE:S Graduate Chair based upon the recommendation of the student's academic advisor.

Minor
For MS Degree: any two from the following: EECS 455, 501, 550, 554, 555, 557, except that the following pair is not allowed: (455,554).
For PhD QUALIFICATION: any one from the following: EECS 501, 550, 554, 555, 557, 650, 651.
For CANDIDACY: any three from the following: EECS 501, 550, 554, 555, 557, 650, 651.

Communications Course Titles:

- EECS 455  Digital Communication Signals and Systems
- EECS 501  Probability and Random Processes
- EECS 502  Stochastic Processes
- EECS 550  Information Theory
- EECS 553  Theory and Practice of Data Compression
- EECS 554  Introduction to Digital Communication and Coding
- EECS 555  Digital Communication Theory
- EECS 557  Communication Networks
- EECS 564  Estimation, Filtering, and Detection
- EECS 600  Function Space Methods in System Theory
- EECS 650  Channel Coding Theory
- Math 451  Advanced Calculus I
**SIGNAL PROCESSING**

**Major**

For MS Degree: EECS 501 and EECS 551, and one more from: EECS 442, 451, 502, 516, 542, 545, 553, 556, 559, 564, 600, 659.

For PhD QUALIFICATION: EECS 501 and EECS 551, and one more from: 502, 516, 545, 553, 556, 559, 564, 659.


Alternatively, the student may elect other courses having significant signal processing content and/or relevant to the student's area of research. Permission to take such courses must be obtained from the EE:S Graduate Chair based upon the recommendation of the student's academic advisor.

**Minor**

For MS Degree: two from: EECS 442, 451, 452, 501, 542, 545, 551, 556, 559, 564, 651, 659.

For PhD QUALIFICATION: one from: EECS 501, 545, 551, 556, 559, 651, 659.

For CANDIDACY: three from EECS 442, 451, 452, 501, 542, 545, 551, 556, 559, 564, 651, 659.

**Signal Processing Course Titles**

- EECS 442 Computer Vision
- EECS 451 Digital Signal Processing and Analysis
- EECS 501 Probability and Random Processes
- EECS 502 Stochastic Processes
- EECS 516 Medical Imaging Systems
- EECS 542 Vision Processing
- EECS 545 Machine Learning
- EECS 550 Information Theory
- EECS 551 Mathematical Methods for Signal Processing
- EECS 553 Theory and Practice of Data Compression
- EECS 556 Image Processing
- EECS 558 Stochastic Control
- EECS 559 Advanced Signal Processing
- EECS 560 Linear Systems Theory
- EECS 564 Estimation, Filtering and Detection
- EECS 600 Function Space Methods in System Theory
- EECS 651 Source Coding Theory
- EECS 659 Adaptive Signal Processing
- Math 451 Advanced Calculus I
- Math 651 Topics in Applied Mathematics
- Stat 601 Analysis of Multivariate and Categorical Data
- Stat 605 Advanced Topics in Modeling and Data Analysis
- Stat 610 Statistical Inference
- Stat 611 Large Sample Theory
EE:S MINOR AREAS:

The minor area must be different from the major. Students may select from an area other than the major within EE:S, from the areas below, or from an outside area of concentration with approval.

Biosystems (Biosignals and Imaging)

Minor:

For MS Degree: Two courses from the list below, including at least one 500 level or above.

For CANDIDACY: Three courses from the list below, including at least two at 500 level or above:

EECS 417 Electrical Biophysics
EECS 435 Fourier Optics
EECS 458 Biomedical Instrumentation and Design
EECS 516 Medical Imaging Systems
EECS 545 Machine Learning
EECS 559 Advanced Signal Processing
BME 510 Medical Imaging Laboratory
BME 519 Quantitative Physiology

Other biosignals and imaging courses may qualify with advisor approval

Manufacturing

Minor:

For MS: Two courses from the list below, including one at the 500 level and above.

For CANDIDACY: At least three courses from the list below, with two or more courses at the 500 level or above.

EECS 569 Production Systems Engineering
ME 401 Statistical Methods for Manufacturing Systems
ME 555 Design Optimization
IOE 416 Queuing Systems
IOE 441 Production and Inventory Control
IOE 466 Statistical Quality Control
IOE 541 Inventory Analysis and Control
IOE 616 Queuing Theory
IOE 645 Topics in Reliability and Maintainability
MEMS & Microsystems

Minor:

For MS Degree: At least two courses from the following groups, including at least one course at the 500 level or above.

For CANDIDACY: At least three courses from the following four groups, including at least two courses at the 500 level or above.

Digital Circuits/VLSI: EECS 427, 478, 523, 627
Analog Circuits: EECS 411, 413, 430, 511, 522, 525
Micro fabrication Technology: EECS 421, 423, 425, 512, 513, 514, 515, 517, 523, 528
MEMS: EECS 414, 425, 503, 509, 514, 515, ME 553

EECS 411  Microwave Circuits I
EECS 413  Monolithic Amplifier Circuits
EECS 414  Introduction to MEMS
EECS 421  Properties of Transistors
EECS 423  Solid-State Device Laboratory
EECS 425  Integrated Microsystems Laboratory
EECS 427  VLSI Design I
EECS 430  Radiowave Propagation and Link Design
EECS 478  Logic Circuit Synthesis and Optimization
EECS 503  Introduction to Numerical Electromagnetics
EECS 511  Integrated Analog/Digital Interface Circuits
EECS 512  Amorphous and Microcrystalline Semiconductor Thin Film Devices
EECS 513  Flat Panel Displays
EECS 515  Integrated Microsystems
EECS 517  Physical Processes in Plasmas
EECS 522  Analog Integrated Circuits
EECS 523  Digital Integrated Circuit Tech.
EECS 525  Advanced Solid-State Microwave Circuits
EECS 528  Principles of Microelectronics Process Technology
EECS 627  VLSI Design II
ME  553  Microelectromechanical Systems
Computers

Minor:

For MS Degree: Any two courses from one of the groups listed below, including one at the 500 level.

For CANDIDACY: Any three courses below, including two at the 500 level and at least two from the same group:

- Hardware: EECS 427, 470, 473, 478, 527, 570, 573, 577, 578, 579, 583, 627
- Software: 481, 482, 483, 484, 485, 486, 487, 489, 490, 580, 581, 582, 583, 584, 585, 587, 588, 589, 590, 591
- Theory & Algorithms: EECS 475, 477, 574, 575, 586
- Intelligent Systems: EECS 492, 545, 547, 592, 595

- EECS 427 VLSI Design I
- EECS 470 Computer Architecture
- EECS 473 Advanced Embedded Systems
- EECS 475 Introduction to Cryptography
- EECS 477 Introduction to Algorithms
- EECS 478 Logic Circuit Synthesis and Optimization
- EECS 481 Software Engineering
- EECS 482 Introduction to Operating Systems
- EECS 483 Compiler Construction
- EECS 484 Database Management Systems
- EECS 485 Web Database and Information Systems
- EECS 487 Interactive Computer Graphics
- EECS 489 Computer Networks
- EECS 490 Programming Languages
- EECS 492 Introduction to Artificial Intelligence
- EECS 527 Layout Synthesis and Optimization
- EECS 545 Machine Learning
- EECS 547 Electronic Commerce
- EECS 570 Parallel Computer Architecture
- EECS 571 Principles of Real-Time Computing
- EECS 573 Microarchitecture
- EECS 574 Computational Complexity
- EECS 575 Advanced Cryptography
- EECS 577 Reliable Computer Systems
- EECS 578 Computer-Aided Design Verification of Digital Systems
- EECS 579 Digital System Testing
- EECS 580 Advanced Computer Graphics
- EECS 581 Software Engineering Tools
- EECS 582 Advanced Operating Systems
- EECS 583 Advanced Compilers
- EECS 584 Advanced Database Systems
- EECS 586 Design and Analysis of Algorithms
- EECS 587 Parallel Computing
- EECS 588 Computer and Network Security
- EECS 589 Advanced Computer Networks
- EECS 590 Advanced Programming Languages
- EECS 591 Distributed Systems
- EECS 592 Advanced Artificial Intelligence
- EECS 595 Natural Language Processing
- EECS 627 VLSI Design II
**Applied Electromagnetics and RF Circuits**

**Minor:**

For MS Degree: Two courses from the list below, including one at the 500 level and above.

For CANDIDACY: EECS 530; plus two other courses from the list below, including one at the 500 level or above.

- EECS 411 Microwave Circuits I
- EECS 430 Radiowave Propagation and Link Design
- EECS 503 Introduction to Numerical Electromagnetics
- EECS 517 Physical Processes in Plasmas
- EECS 519 Plasma Generation and Diagnostics Laboratory
- EECS 525 Advanced Solid-State Microwave Circuits
- EECS 530 Electromagnetic Theory I
- EECS 531 Antenna Theory and Design
- EECS 532 Microwave Remote Sensing I: Radiometry
- EECS 533 Microwave Measurements Laboratory
- EECS 631 Electromagnetic Scattering
- EECS 632 Microwave Remote Sensing II: Radar
- EECS 633 Numerical Methods in Electromagnetics

**Optics and Photonics**

**Minor:**

For MS Degree: Two courses from the list below, including one at the 500 level and above.

For CANDIDACY: At least three courses from the list below, with two or more courses at the 500 level or above.

- EECS 434 Principles of Photonics
- EECS 435 Fourier Optics
- EECS 438 Advanced Lasers and Optics Laboratory
- EECS 530 Electromagnetic Theory I
- EECS 535 Optical Information Processing
- EECS 536 Classical Statistical Optics
- EECS 537 Classical Optics
- EECS 538 Optical Waves in Crystals
- EECS 539 Lasers
- EECS 540 Applied Quantum Mechanics I
- EECS 546 Ultrafast Optics
- EECS 552 Fiber Optical Communications
- EECS 634 Nonlinear Optics
- EECS 638 Quantum Theory of Light

**Solid-state**
**Minor:**

For MS Degree: At least two courses from the list below, including one at the 500 level or above, not more than one two-hour laboratory course.

For CANDIDACY: At least three courses from the list below, including at least two at the 500 level or above, and not more than one two-hour laboratory course.

- EECS 420 Physical Principles Underlying Smart Devices
- EECS 421 Properties of Transistors
- EECS 423 Solid-State Device Laboratory
- EECS 425 Integrated Microsystems Laboratory
- EECS 429 Semiconductor Optoelectronics Devices
- EECS 512 Amorphous and Microcrystalline Semiconductor Thin Film Devices
- EECS 513 Flat Panel Displays
- EECS 517 Physical Processes in Plasmas
- EECS 520 Electronic and Optical Properties of Semiconductors
- EECS 521 High-Speed Transistors
- EECS 523 Digital Integrated Technology
- EECS 525 Solid State Microwave Circuits
- EECS 528 Principles of Microelectronics Process Technology
- EECS 529 Semiconductor Lasers and LEDs
- EECS 540 Applied Quantum Mechanics I
COGNATES

The following EECS courses are not acceptable as cognates for EE:Systems Students. In general any graduate level EECS course that is not on this list is acceptable as a cognate, but students should check with an academic advisor for approval for all cognate courses. It is permissible to use a minor kernel course as a cognate provided the minor is outside EE:S (i.e. not control, communications, signal processing) and is beyond the 2 courses required for the minor.

Courses Associated with the EE:S Graduate Program

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<td>EECS 419</td>
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<td>EECS 458</td>
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<td>EECS 461</td>
<td>Embedded Control Systems</td>
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<tr>
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<td>EECS 500</td>
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FACULTY/ADVISOR/STAFF INFORMATION

EECS Faculty Directory:
http://www.eecs.umich.edu/eecs/faculty/faculty.html

Academic Advisor:

In EE:S, there is a distinction between the academic and the research advisor. The academic advisor's primary duty is to help design an academic program to meet a student's goals within the course requirements of the graduate program. The academic advisor will also counsel students on the qualifying exams required for the PhD and can offer advice on the research interests of the faculty. There is one academic advisor assigned to each of the three major areas of study.

Research Advisor:

For those students pursuing the PhD, the Research Advisor fulfills two separate advising roles. As a precandidate, the Research Advisor is the Directed-Study Advisor, overseeing the Qualifying Exam II research and examination. As a candidate, the Research Advisor is the Dissertation Advisor, overseeing thesis research. For most students, the Directed-Study Advisor and Dissertation Advisor are the same faculty member.

EE:S Graduate Chair: Prof. Demosthenis Teneketzis

The EE:S Graduate Chair oversees the running of the Systems Graduate Program, including the academic kernels, qualifying examinations, recommendation of degrees to the Rackham Graduate School, financial aid, and petitions for changes in the degree requirements. The Graduate Chair heads the Graduate Committee made up of each area's academic advisor, the financial aid chair, and the admissions co-chairs in the implementation of policies set by the faculty of the EE:S Program. In addition to this smaller committee, the Graduate Chair heads a committee-of-the-whole made up of the entire EE:S faculty in matters of policy development, and most importantly, granting of Ph.D. candidacy through the two qualifying exams.

ECE Financial Aid Graduate Coordinator: If you have received departmental financial aid, meet with:

If you received Fellowship: Rachel Antoun (EE:S), EECS 3404 or Steve Pejuan (EE), EECS 3403
If you received Graduate Student Instructor (GSI): Anne Rhoades – EECS 3300 or 3709 BBB
If you received Graduate Student Research Assistant (GSRA) position -- Your faculty advisor and his/her lab administrator

EE:S PhD Graduate Program Coordinator: Rachel Antoun (yangrc@umich.edu)
EE:S MS Graduate Program Coordinator: Kevin Calhoun (kacalh@umich.edu)

The Graduate Program Coordinators are the primary contact persons for the EE:S graduate program. The EE:S Graduate Program Coordinators will process paperwork and are an important resource concerning general questions about the graduate programs.