

# GRADUATE HANDBOOK

## M.S. and Ph.D. Programs in Electrical Engineering at Michigan State University

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## **1. PROGRAM OVERVIEW**

### **1.1 Advantages of a graduate degree in Electrical Engineering**

A graduate degree in Electrical Engineering opens doors that are not otherwise accessible. These opportunities include research positions at corporations and national laboratories as well as teaching and research positions in academia. A career at this level brings the satisfaction of being able to explore your own ideas and fully utilize your creativity. A graduate degree will allow you to expand your knowledge and acquire new skills in analysis and problem solving, creating challenging opportunities for a full, rewarding career. Dr. Brian Kent, an MSU alumnus and now a U.S. Air Force Research Leader notes, "My USAF work experience showed me that the primary researchers, decision makers, and program managers all shared one trait...they held advanced academic degrees in engineering".

First and foremost among the talents required to succeed in a graduate program is a desire to learn, coupled with a natural curiosity and a desire to advance the state-of-the-art. Graduate students are motivated by the enhanced independence that an advanced degree brings and the challenge of placing oneself at the forefront of technology.

We have designed this Handbook to help prospective and current graduate students select an appropriate graduate program and provide information about the educational, research and work opportunities available in the Department. We thank you for considering our graduate program. All the best in your engineering career!

#### **NOTICE:**

Deadlines for applying for admission to the Electrical Engineering Graduate Program at Michigan State University are provided in Section 3.1 of this Handbook.

**The most recent version of this document and additional information can be found at <http://www.eqr.msu.edu/ece>**

### **1.2 The Electrical Engineering Graduate Program at Michigan State University**

The Department of Electrical and Computer Engineering offers graduate programs leading to the Master of Science and Doctor of Philosophy graduate degrees. Graduate study in the Department is organized into three groups: Computer Engineering, Electrosiences, and Systems. Within these groups are areas of specialization, as follows:

- Computer Engineering
  - o Computer Architecture
  - o Computer Networks
  - o VLSI/Microelectronics
- Electrosiences
  - o Electromagnetics
  - o Electronic Materials and Devices
- Systems
  - o Control and Robotics
  - o Biomedical Engineering
  - o Power
  - o Signal Processing and Communications

An interdisciplinary approach marks many of the research projects that faculty share with graduate students.

Our graduate program is built on the quality of our faculty, our graduate students, and the quality of their collaborative research. We believe that the background and interests of our faculty, the research facilities, and the academic excellence of our students make our Department an attractive environment for graduate study. As a Department, we look ahead to the future knowing that change and growth are important aspects of and inevitable in our discipline. The Department currently has approximately 40 faculty members, 840 undergraduates, and 180 graduate students, with a strong commitment to the importance of diversity among peers and faculty for the professional development of all graduate students. A graduate degree at MSU will enable you to develop the intellectual skills you need to compete among the best engineers in the world and you will receive world-class training preparing you for a fulfilling career in industry, research, or teaching.

### **1.3 Student participation**

The Department's graduate degree programs have certain course requirements as outlined in detail in Section 3. However, graduate students in the Department quickly discover that their education is advanced in a number of ways beyond traditional coursework. One of the major opportunities is the chance to work side by side with faculty members who are deeply interested in finding answers to research problems. Most M.S. students are expected to be involved in thesis work and all doctoral students are involved in dissertation research. In addition, the Department regularly sponsors seminars, which bring speakers from around



the world to campus. All first year graduate students are required to attend these seminars, and other students are encouraged to attend them. Faculty, as well as students, participate in these out-of-class learning experiences. Doctoral students demonstrate mastery of the subject matter at various levels by passing a qualifying exam and a comprehensive exam. They also develop a dissertation proposal and present the results of their research in a dissertation defense. Students are encouraged to participate in professional society meetings and to publish their research results in society journals, transactions, and conference proceedings.

Graduate students also have the opportunity to participate in academic governance at the Department, College, and University level. At the Department level, a graduate student representative participates as a voting member of the Electrical and Computer Engineering Graduate Studies Committee. Electrical engineering graduate students elect this representative from a slate of nominees, which is prepared by the graduate student body. This committee makes recommendations to the faculty on graduate academic standards, graduate course additions, deletions, and modifications, and graduate degree requirements. At the College level, graduate students have representation on the Engineering College Advisory Council and on the Engineering Research and Graduate Studies Committee. At the University level, graduate students are selected and have voting membership on the University Graduate Council, Academic Council, and other such committees as specified by the University Bylaws for Academic governance.

### **1.4 A road map to your degree**

The typical path toward a master's degree in electrical engineering at Michigan State University is as follows. This path is for a master's degree with thesis, which is the option most often selected.

- Gain admission to the program with financial support. For most of our admitted students, the support is in the form of a graduate assistantship.
- Obtain an academic advisor. Your advisor will be a member of the Department faculty.
- Design a program of coursework with your advisor. The Master's Degree Program Plan is to be submitted by the end of your first semester at the web site <https://www.egr.msu.edu/apps/gts2/>. See also Appendix 4 in this handbook.
- Complete the required coursework and your thesis research. The sample master's programs in Appendix 3 outline courses and thesis work over 4 semesters, including summer. At the end of the program, the thesis is defended in an oral examination. Actual student programs often represent variations on these sample programs, with the variations representing the

individual student's interests. Most master's degree students in our program finish within two years.

- Submit an Application for Graduation with the Office of the Registrar by the first week of the semester you expect to complete your degree requirements. If you will complete your degree requirements during summer, apply for summer by the first week of spring semester. Both spring and summer applicants will be included in the Spring Commencement Ceremonies. The application may be done on line at: <https://www.reg.msu.edu/StuForms/GradApp/GradApp.asp>. For students who were enrolled in the spring and are defending their dissertations during the immediate summer semester, the department can request a waiver of the requirement that the student be enrolled for at least one credit the semester of the defense. These requests are to be directed to the graduate school and must be endorsed by the student's department and college. Two bound copies of your thesis must be provided to the ECE Graduate Secretary before the degree certification is authorized.

The typical path toward a doctorate degree in electrical engineering at Michigan State University is as follows.

- Gain admission to the program with financial support. For most of our admitted students, the support is in the form of a graduate assistantship.
- Identify an academic advisor. Your advisor will be a member of the Department faculty and will serve as the chairperson of your doctoral guidance committee.
- Form a guidance committee.
- Design a program of coursework with your guidance committee before the end of your second semester. The Doctoral Degree Program Plan is accessed at the web site <https://www.egr.msu.edu/apps/gts2/>. See also Appendix 5 in this handbook.
- Pass the doctoral qualifying examination part A. This exam must be taken no later than the first offering after the completion of your first semester in the program.
- Pass part B of the doctoral qualifying examination by the end of the third semester.
- Pass the comprehensive examinations, including a successful presentation of a dissertation proposal. This is done when coursework is finished, or substantially finished.
- Complete your research, write your dissertation, and defend it in an oral examination. Historically, a doctoral program at MSU requires an average of approximately four years to finish.

- Submit an Application for Graduation with the Office of the Registrar by the first week of the semester you expect to complete your degree requirements. If you will complete your degree requirements during summer, apply for summer by the first week of spring semester. Both spring and summer applicants will be included in the Spring Commencement Ceremonies. The application may be done on line at: <https://www.reg.msu.edu/StuForms/GradApp/GradApp.asp>. For students who were enrolled in the spring and are defending their dissertations during the immediate summer semester, the department can request a waiver of the requirement that the student be enrolled for at least one credit the semester of the defense. These requests are to be directed to the graduate school and must be endorsed by the student's department and college. Two bound copies of your dissertation must be provided to the ECE Graduate Secretary before the degree certification is authorized.

### **1.5 For further information**

As you read this handbook, please don't hesitate to contact the Department's Associate Chairperson for Graduate Studies, any of our faculty members, or the Graduate Secretary for more information.

In addition to this handbook, the following relevant publications and resources are available on-line:

Michigan State University Office of the Registrar  
(<http://www.reg.msu.edu/ucc/ucc.asp>)

Michigan State University Description of Courses Catalog  
(<http://www.reg.msu.edu/Courses/Search.asp>)

Michigan State University Schedule of Courses  
(<http://schedule.msu.edu/>)

The Graduate School  
(<http://grad.msu.edu/>)

Graduate Students Rights and Responsibilities  
(<http://www.vps.msu.edu/SPLife/grr1.htm>)

Guidelines for Integrity in Research and Creative Activities  
(<http://grad.msu.edu/researchintegrity/docs/ris04.pdf>)

MSU/Graduate Employees Union Contract  
([http://www.hr.msu.edu/documents/contracts/GEU\\_2008-2011.pdf](http://www.hr.msu.edu/documents/contracts/GEU_2008-2011.pdf))

Student Services  
(<http://www.vps.msu.edu/>)

Academic Freedom for Students at Michigan State University  
(<http://www.vps.msu.edu/SPLife/acfree.htm>)

Tuition, Fees, and Housing Calculator (<http://ctrl.msu.edu/COStudentAccounts/>)

Council of Graduate Students (COGS)  
(<http://cogs.msu.edu/>)

Office for International Students and Scholars at Michigan State University  
(<http://www.oiss.msu.edu/>)

PREP program for graduate students' professional development  
(<http://grad.msu.edu/cpd.htm>)

Publishing agreement for thesis/dissertations with ProQuest  
([http://proquest.com/products\\_umi/dissertations/epoa.shtml](http://proquest.com/products_umi/dissertations/epoa.shtml))

MSU Travel Clinic  
(<http://www.travelclinic.msu.edu/>)

Note: If traveling abroad,

1. Check with the MSU Travel Clinic. They will let you know of any health risks or immunizations.
2. Check the International Studies and Programs website for issues related to safety around the world.
- 3.** Apply for assistance with travel funding via the Graduate School. If the Graduate School provides funding, they will also provide a MEDEX emergency card.

## **2. PROGRAM COMPONENTS**

### **2.1 Doctor of Philosophy graduate program**

The Doctor of Philosophy degree consists of (1) prescribed course work, (2) a qualifying examination (parts A and B), (3) a comprehensive examination, (4) research, (5) a dissertation, and (6) a final oral examination. Each student working toward a Doctor of Philosophy must conduct research upon which a dissertation that makes a significant contribution to knowledge is prepared and published. The research is to be under the direction of the doctoral guidance committee and acceptable to the doctoral guidance committee.

The courses prescribed by the student's guidance committee are listed on the student's College of Engineering Doctoral Degree Program Plan, which is signed by the student, members of the guidance committee, the Department chairperson, and the Associate Dean. Further information about the required coursework is in Section 3 of the handbook, and further information about the guidance committee formation is in Section 5 of the handbook. The final oral examination is described in Section 6.

#### **2.1.1 The Ph.D. Qualifying Examination**

Format and purpose of the Ph.D. qualifying examination: The exam shall consist of two parts. Part A will be closed book, written exam, prepared by groups of faculty selected by the Graduate Studies Committee. Part B will have written and oral components and will be based on a research project conducted by the student under the guidance of a faculty advisor. The overall objective of the qualifying exam is to assess a student's potential for successfully completing doctoral-level studies and research in the Department. The primary objective of part A is to assess the student's ability to prepare and grasp a broad range of fundamental topics in electrical and computer engineering. The primary objective of part B is to assess the student's potential for addressing research problems.

Part A qualifying examination format: The exam will be administered once each year in January approximately during the third week of classes. The exam will last three hours and will consist of one set of questions in each of the two fundamental areas:

Circuit Fundamentals  
Digital Logic Fundamentals

and one set of questions in each of the eight focus areas:

Computer Architecture  
Computer Networks  
Control

Electromagnetics  
Electronic Devices  
Microelectronic Circuits and VLSI  
Power Systems  
Signal Processing & Communication

Each exam area will be based on undergraduate course material and workable in 45 minutes. Each student must complete four exams including at least one fundamental area. The choice of which of the four exams to be attempted is to be made by the student in consultation with their major advisor. Only those areas identified by the student to be graded will be graded.

Evaluation of part A qualifying examination: The Department's Graduate Studies Committee will evaluate the student's performance in Part A of the exam. In arriving at its decision, the committee will use a numerical score on a scale of zero to 100, based on 25 points for each of the four chosen exams. Decisions by the committee will fall into one of the following three categories:

**QP2:** A student passes part A of the exam if a score of at least 50% is achieved in each of the four exams. The student is encouraged to continue in the Ph.D. program and take part B of the exam.

**QP1:** A student passes part A of the exam but is required, on the basis of the student's exam scores, to take prescribed course(s). Remedial coursework will be assigned at the discretion of the Graduate Studies Committee. This will typically be one undergraduate course for each exam on which the student scored less than 50%. Two courses may be prescribed if the score is less than 25%, however, the maximum number of remedial courses will not exceed five. Assigned remedial courses must be completed within one year. Moreover, the student must earn at least a 3.0 grade in each of the prescribed courses. The student is encouraged to continue in the Ph.D. program and take part B of the exam.

**QP0:** If a student scores less than 25% on all four exams, the student does not pass part A of the exam and will be required to withdraw from the Ph.D. program at the end of the present semester.

Schedule of part A qualifying examination: Part A of the Ph.D. qualifying exam is offered once a year, approximately in the third the spring semester. All Ph.D. program students are required to take the exam no later than the first offering after completing their first semester in the program.

Appeal of part A qualifying examination results: A student may review his/her graded Ph.D. qualifying examination by contacting the Associate Chair for Graduate Studies. If after reviewing the exam, a student believes that an appeal on the exam outcome is warranted, such an appeal must be made in writing and directed to the Associate Chair. The written appeal must contain explicit reasons for requesting that the review be conducted. The appeal must be filed within two

weeks from the date the student is notified of the Ph.D. part A qualifying examination results.

Format of part B qualifying examination: After passing part A of the exam, the Associate Chair for Graduate Studies, in consultation with the student's major advisor, will choose a faculty supervisor and two other faculty members to evaluate part B of the exam. The faculty supervisor will assign a research topic to the student, who will research the topic, submit a written report describing his/her approach to addressing the research problem, and make an oral presentation in front of an evaluation committee.

An exception in the assignment of an exam topic may be made if the student has published at least two refereed conference papers or at least one archival journal publication. In this case the student will be asked to submit a written report describing his/her contribution to the research publication(s), and make an oral presentation on the topic in front of the evaluation committee.

Also, upon recommendation of the MS thesis defense committee, an MSU ECE MS thesis and defense can be submitted in fulfillment of part B of the Ph.D. qualifier exam.

Evaluation of part B qualifying examination: Decisions by the committee will fall into one of the following three categories:

1. A student passes part B of the exam and is encouraged to continue in the Ph.D. program, form a guidance committee if one does not already exist, and begin preparation for the comprehensive exam and thesis research.
2. A student does not pass part B of the exam but is granted an extension, up to one month, with conditions and/or requirements specified by the committee, for satisfactory completion of part B.
3. A student does not pass part B of the exam and is asked to withdraw from the Ph.D. Program at the end of the present semester.

Schedule of part B qualifying examination: After passing part A of the exam, the student has until the end of the next fall semester to satisfy the part B requirement.

Time limit: If a student leaves the graduate program after passing the qualifying examination and then wishes to reenter the doctoral program at a later date, a pass of part A and part B will be considered valid up to 5 years from the time of taking the examination.

### 2.1.2 Doctoral Comprehensive Exam and Dissertation Proposal

The intent of the Ph.D. comprehensive examinations is (a) to identify the student's proposed areas of doctoral research; (b) to assess the adequacy of the student's general preparation for the proposed research area and related fields and possibly recommend areas for additional study; and (c) to review and

evaluate the content and style of the thesis proposal and the student's ability to present the ideas orally.

Schedule of the comprehensive examination: When the prescribed course work is substantially complete as defined by the Guidance Committee, the doctoral student is eligible to take the comprehensive examinations. There must be at least a six-month period between the date when the comprehensive examinations have been successfully completed and the final thesis defense.

Format of the comprehensive examination: A doctoral student's comprehensive examinations decompose into several distinct components:

- A written thesis proposal that is prepared by the student and presented to the Guidance Committee for review and evaluation.
- An oral presentation of the thesis proposal, which occurs at least two weeks after the written thesis proposal is submitted to the Guidance Committee.
- An oral and/or written examination(s) to assess the student's preparation in the major and related field(s) of study for conducting the proposed research.

The Guidance Committee will decide whether or not this third portion of the comprehensive examinations will be written or oral and whether or not it will be conducted before, after, or at the same time as the oral presentation of the thesis proposal. Passing the comprehensive examinations shall require:

1. Satisfactory performance on the oral thesis proposal presentation.
2. Satisfactory performance on the formal examination.
3. A satisfactory written thesis proposal, a copy of which will be placed in the student's file.

Evaluation criteria for the comprehensive examination. The Committee will consider all of the information available to it, including an interview with the student to clarify unresolved issues, and render one of the following decisions:

1. The student passes the exams and is encouraged to finish all remaining requirements at the earliest possible time.
2. The student passes the exams and, except for identified deficiencies for which the Committee will prescribe a remedy, the student is encouraged to finish all remaining requirements at the earliest possible time.
3. The student fails the exams but is given permission to repeat a portion or all of them after certain conditions are met.
4. The student fails the exams and is asked to withdraw from the program at the end of the term.



Passing the comprehensive examinations requires approval of at least two thirds of the student's guidance committee.

Appeals of the comprehensive examination evaluation: A student may appeal the Guidance Committee's decision. Such an appeal must be made in writing and directed to the Department Chairperson. The written appeal must contain explicit reasons for requesting that the review be conducted. The appeal must be filed within two weeks from the date the student is notified of the Guidance Committee's decision.

#### 2.1.3 Doctoral Course Work

Courses will be prescribed by the guidance committee to ensure that the student has a comprehensive knowledge of a major research field and related subjects. The required courses will depend upon the student's academic background in relation to the selected research specialization. For minimum Department requirements, see section 3 of this handbook. For sample doctoral program course work, please see Appendix 5.

#### 2.1.4 Doctoral Research

Each student working toward a Doctor of Philosophy must conduct research upon which a dissertation that makes a significant contribution to knowledge is prepared and published. The research is to be under the direction of and acceptable to the doctoral guidance committee.

#### 2.1.5 Doctoral Final Oral Examination

The graduate student will present the results of the thesis/dissertation in a seminar open to the community. The examination committee evaluates the seminar and defense of the thesis. For more information, see section 6 of this handbook.

#### 2.1.6 Doctoral Dissertation

An approved thesis/dissertation that is accepted by the graduate school becomes a single-author publication and contributes to the body of knowledge of electrical engineering. Again, for more information, please see section 6 of this handbook.

## **2.2 Master's Plan A**

The Master's plan A program consists of prescribed course work, research, a master's thesis, and an oral defense of the master's thesis. For more information about the prescribed course work, please see Section 3. The oral defense is described in Section 6.

## **2.3 Master's Plan B**

The Master's plan B program consists of prescribed course work as described in Section 3, and a final evaluation of the student's program. The final evaluation is done by the academic advisor and the Department's Associate Chairperson for Research and Graduate Studies.

### **3. DEGREE REQUIREMENTS**

#### **3.1 Admission**

##### **3.1.1 Admission Requirements**

Regular admission status: Admission to a graduate degree program with regular status may be granted by the Department, subject to the availability of resources and to the approval of the Dean of Engineering, upon consideration of the likelihood that the applicant will be able to pursue a master's program successfully without taking collateral courses. Most domestic applicants have undergraduate grade point averages of 3.5 or higher and are highly ranked in their bachelor's class. A general profile of a successful international student applicant is as follows: graduate of a highly ranked school; in the upper 10% of their class; TOEFL scores higher than 600 (paper) or 250 (computer); GRE quantitative/verbal/writing scores greater than 750/500/4.

For admission to the Master's program, students should have a four-year bachelor's degree in Electrical Engineering or a closely related field. For admission to the doctoral program, students generally will have also completed the master's degree or equivalent in electrical engineering. However, students with both a strong background and a strong commitment to the doctoral program may apply directly to the doctoral program without completion of a Master's degree.

Provisional admission status: Admission to a graduate degree program with provisional status may indicate that collateral work is required or that the student's record has not yet been fully evaluated. If collateral courses are required, the minimum acceptable grades and the semesters by which those courses must be completed will be specified on the admission form. The provisional status will be changed to regular status when the conditions specified on the admission form have been met, as determined by the Department and approved by the Dean of Engineering.

Proficiency requirement: Regardless of whether admission status is regular or provisional, students whose undergraduate degree is not in Electrical or Computer Engineering must, during their course of study, demonstrate proficiency in 3 out of the following courses: ECE 302 (Electronic Circuits); ECE 305 (Electromagnetic Field and Waves); ECE 313 (Control Systems); ECE 366 (Signal Processing). Proficiency is shown by (i) enrolling for the class and receiving a passing grade, or (ii) taking the class final examination along with the students enrolled in the class at the regularly scheduled final examination time and passing the exam, or (iii) having a substantially identical class on record on an official transcript.

### 3.1.2 Applying For Admission As A Student New To MSU Graduate Programs

Deadlines for graduate applications: For admission in fall semester, applications must be received in complete form by January 15th of the preceding spring term. For admission in spring semester, applications must be received in complete form by September 15th of the preceding fall term.

Application Materials: Note that all the following items are required for a complete application and that incomplete applications are not reviewed. The following procedure is for any student new to the MSU graduate school. For additional instructions and form access, please see the following web site: <http://www.egr.msu.edu/academics/graduate/how-to-apply>.

- i. Applicants should submit a completed on-line application form on-line at **MSU Graduate Admissions** (<http://grad.msu.edu/apply/>) along with an application fee as stipulated on that web site (\$50). On-line applications are required except for those international students living in areas where internet access presents a very serious logistics problem. In that case, please send a request for a mail-in application. However, be advised that a mail-in application may result in a delay in consideration of the application which may have an impact on funding. The fee for a paper application is also \$50. The on-line application goes directly to the MSU Graduate School and is subsequently forwarded by the Graduate School to the Electrical and Computer Engineering Department. Please note that all applicants must submit a Personal Statement with the on-line application explaining your reasons for seeking graduate program enrollment and your career objectives.
- ii. Applicants must also submit an on-line 'Graduate Admissions, Recruitment, and Financial Aid Information Sheet' at the following web site, (<http://www.egr.msu.edu/academics/graduate/how-to-apply>). Note that this is a secure site and that the completed on-line form is transmitted to the Electrical and Computer Engineering Department Graduate Admissions Secretary when submitted.)

In addition to the above on-line items, the following 4 items must be submitted to the mail address listed below:

Department of Electrical & Computer Engineering  
Attn: ECE Graduate Application Processing  
2120 Engineering Building  
Michigan State University  
East Lansing, MI 48824-1226

- iii. Three recommendation forms must be completed by instructors or supervisors familiar with the applicants work. The e-mail address of the recommender must be provided on the form. The recommendation form is available on-line at:

[http://www.egr.msu.edu/ece/files\\_ece/ECEGraduateApp-RecommendationForm\\_0.pdf](http://www.egr.msu.edu/ece/files_ece/ECEGraduateApp-RecommendationForm_0.pdf) and is also included in Appendix 6 of this Handbook. Please provide a copy of the recommendation form and envelope with the above address to the recommender. For applicants from international schools, this form must be accompanied by letters of recommendation on official stationery from the recommender's institution.

- iv. Two official copies of transcripts from all previous universities attended. (This is not necessary for courses taken at Michigan State University, because the Department Admissions Secretary has access to Michigan State University course records.)
- v. Graduate Record Examination (GRE) aptitude scores are required for all international Applicants and for all other applicants with an undergraduate degree from an international school. The GRE is recommended for all other applicants. GRE test scores must be provided to us directly by the Educational Testing Service.
- vi. TOEFL Scores are required for all international applicants who are on an F-1 visa from a non-English speaking country. TOEFL test scores must be provided to us directly by the Educational Testing Service.

**Note that items i. through vi. above, are required for a complete application to be considered for admissions. We do not waive these requirements, nor can the application fee be waived.**

### 3.1.3 Applying For Transfer To Electrical Engineering From Another MSU Graduate Program

The expected qualifications for current MSU graduate students seeking to transfer to a M.S. or Ph.D. program in Electrical Engineering (E.E.) are similar to the qualifications expected for applicants applying to the program in general. Department proficiency requirements, support requirements, and application deadlines also apply. However, the application procedure is different because the applicant is already a student at MSU.

#### Application Procedure for transfer from another MSU graduate program:

Fill out a paper copy of the MSU "Application for Admission to Graduate Study". Do not send this to the Admissions Office since you are already a student at MSU. Also do not include any fee. Instead, write "Transfer" on top of the form. Include the items below with your application to the Electrical Engineering Graduate Program.

1. The paper copy of the MSU application.
2. Official transcripts from schools attended other than MSU.

3. Proof of GRE and TOEFL scores if you are an international student.
4. Three recommendation forms must be completed by instructors or supervisors familiar with the applicants work. The e-mail address of the recommender must be provided on the form. The recommendation form is available on-line at <http://www.egr.msu.edu/ece/students/recommend.pdf> and is also included in Appendix 6 of this Handbook. Please provide a copy of the recommendation form and envelope with the above address to the recommender. For applicants from international schools, this form must be accompanied by letters of recommendation on official stationery from the recommender's institution.
5. A statement of purpose as described on the ECE web page regarding instructions for applying to graduate school.
6. Submit a completed on-line 'Graduate Admissions, Recruitment, and Financial Aid Information Sheet' at the web site (<https://www.egr.msu.edu/apps/gts/apply/>). Note that this is a secure site and that the completed on-line form is transmitted to the Electrical and Computer Engineering Department Graduate Admissions Secretary when submitted.)

Make an appointment with the ECE Associate Chairperson for and provide the items 1 through 5. The ECE Graduate Admissions, Recruitment and Financial Aid Committee will consider the application after all items 1 through 6 are received.

Support and Degree Requirements for transfer from another MSU graduate program:

Admission is tied to Department financial support in the form of fellowships or graduate assistantships. All degree requirements described in this Handbook must be met. In addition to the regular degree requirements, the following applies for students transferring from another MSU graduate program.

- At least 12 credits of the program must involve courses for which a grade has not yet been received prior to admission.
- An ECE advisor must be assigned and a second M.S. program must be filed before half the required minimum of 21 credits of related ECE course materials are completed.
- Proficiency must be demonstrated in 3 out of the following courses: ECE 302, ECE 305, ECE 313, ECE 366.

#### 3.1.4 Applying For A Second, Joint, Or Dual Master's Degree From MSU

The expected qualifications for current MSU graduate students seeking admission for a second, joint, or dual M.S. degree in Electrical Engineering (E.E.) are similar to the qualifications expected for applicants seeking a M.S. in E.E. in general. Department proficiency, support requirements, and application deadlines also

apply. However, the application procedure is different because the applicant is already a student at MSU.

Application procedure for a second master's degree:

Fill out a paper copy of the MSU "Application for Admission to Graduate Study". Do not send this to the Admissions Office since you are already a student at MSU. Also do not include any fee. Instead, write "Second Masters" on top of the form. Include the items below with your application:

1. The paper copy of the MSU application.
2. Official transcripts from schools attended other than MSU.
3. Proof of GRE and TOEFL scores if you are an international student.
4. Three recommendation forms completed by instructors or supervisors familiar with the applicants work. The e-mail address of the recommender must be provided on the form. The recommendation form is available on-line at [http://www.egr.msu.edu/ece/files\\_ece/ECEGraduateApp-RecommendationForm\\_0.pdf](http://www.egr.msu.edu/ece/files_ece/ECEGraduateApp-RecommendationForm_0.pdf) and is also included in Appendix 6 of this Handbook. Please provide a copy of the recommendation form and envelope with the above address to the recommender. For applicants from international schools, this form must be accompanied by letters of recommendation on official stationery from the recommender's institution.
5. A statement of purpose as described on the ECE web page regarding instructions for applying to graduate school.
6. A letter of support from your faculty advisor or graduate coordinator in your current major Department.
7. Submit a completed on-line 'Graduate Admissions, Recruitment, and Financial Aid Information Sheet' at the web site: <https://www.gims.msu.edu/egr/apply/welcome.do>. Note that this is a secure site and that the completed on-line form is transmitted to the Electrical and Computer Engineering Department Graduate Admissions Secretary when submitted.

Make an appointment with the ECE Associate Chairperson for Research and Graduate Studies and provide items 1 through 6. The ECE Graduate Admissions Recruitment and Financial Aid Committee will consider the application after all items 1 through 7 are received.

Support and Degree Requirements for second, joint, and dual master's degrees:

Admission is tied to Department financial support in the form of fellowships or graduate assistantships. Exceptions are provided for comparable support from external scholarships or fellowships for graduate study in Electrical Engineering, and for doctoral students supported in their major Department. All degree requirements described in this Handbook must be met. In addition to the regular degree requirements, the following applies for second, joint, and dual master's

degrees programs.

- The master's plan must include at least 21 credit hours of material related to electrical engineering and not included in the student's other graduate degree program.
- At least 12 credits of the program must involve courses for which a grade has not yet been received prior to admission.
- An ECE advisor must be assigned and a second M.S. program must be filed before half the required 21 credits of related ECE course materials are completed.
- Proficiency must be demonstrated in 3 out of the following courses: ECE 302, ECE 305, ECE 313, ECE 366.

### 3.1.5 Applying For A Dual Major Doctoral Degree From MSU

Under Michigan State University guidelines, doctoral degrees can be designed across disciplines/graduate programs with the concurrence of the graduate programs involved (see "Dual Major Doctoral Degrees in the MSU publication Academic Programs). All dual major doctoral degrees must be approved by the Dean of the Graduate School. A request for the dual major degree must be submitted within one semester following its development and within the first two years of the student's enrollment at MSU. For further information regarding dual major doctoral degrees where one of the majors is Electrical Engineering, please see Appendix 6 of this handbook.

## 3.2 Department admission selection process

The admission selection process is a two-step process that is tied both to the qualifications of the applicant and to the availability of graduate assistantships and fellowships. As a first step, the Department's Graduate Admissions, Recruitment and Financial Aid Committee (GARFAC) reviews each complete application with regard to whether the background indicates the likelihood of a positive experience in the graduate program. This decision is based on a number of considerations including the previous educational institution, courses of study at that institution, rank in class, GRE and TOEFL scores, and references.

If the applicant's background is considered to be compatible with the program, then in the second step of the admission process the candidate is considered for financial support. It is the general policy of the Department to only offer admission if full support in the form of a graduate assistantship or fellowship is available. This may include fellowships or scholarships from other organizations. Identifying such support constitutes the second step of the admission process. Faculty review the candidates with regard to offering a research assistantship and GARFAC reviews the candidates with regard to teaching assistantship and



fellowship offers.

### **3.3 Requirements for the Master's degree, Plan A**

The Plan A master's degree consists of prescribed course work, research, thesis, and a final oral examination.

Master's credit requirements: The student must complete at least 30 credits at the 400 level or higher. At least 20 of these credits, including the thesis credits, must be at the 800 level or higher. In addition, credit requirements for core-courses, supporting courses, and the master's thesis must be met. Courses below the 400 level may not be counted toward the requirements of the degree. Please see Appendix 4 for a work sheet to help plan your course of study for the M.S. in Electrical Engineering. The allocation of the credits is described as follows.

Master's ECE courses: Students are required to take a minimum of four ECE courses (12 credits minimum) at the 800 or 900 level, not including ECE 801. These courses must include at least two classes from the following list of core courses:

ECE 813	Advanced VLSI Design
ECE 820	Advanced Computer Architecture
ECE 821	Advanced Power Electronics and Applications
ECE 851	Linear Control Systems
ECE 835	Advanced Electromagnetic Fields and Waves I
ECE 863	Analysis of Stochastic Systems
ECE 874	Physical Electronics

Master's supporting classes: At least two classes (6 credits minimum) of supporting classes outside of the Engineering College are required in areas such as Mathematics, Statistics, and Physics. Examples of approved courses are as follows:

MTH 415, 421, 424, 425, 428H, 443, 451, 452, 461, 472  
MTH 810, 828, 829, 841, 842, 848, 849, 850, 851, 852, 881  
STT 441, 442, 844, 861, 862  
PHY 425B, 471, 472, 810, 841, 842, 851, 852

Master's thesis credit requirements: At least 4 credits and no more than 8 credits of ECE 899 are required.

Master's transfer credits: As many as 9 semester credits of graduate course work (excluding research and thesis credits) may be transferred into a 30 credit master's degree program from other accredited institutions or international institutions of similar quality if they are appropriate to a student's program and provided they were completed within the time limits for the degree. Such courses

must have been taken while enrolled in a graduate degree program or while dual-enrolled in a graduate program and an undergraduate program. Courses taken in an undergraduate program are not transferable. An undergraduate program is one in which the degree granted is a bachelor's degree, regardless of the number of credits or years.

See the MSU Academic Programs publication for additional information. If you wish to transfer credits, see the Associate Chairperson for Research and Graduate Studies at the beginning of the program so that an MSU Credit Evaluation form can be initiated. (See the form in Appendix 7 of this Handbook.)

As a member of the Michigan Coalition for Engineering Education (MCEE), MSU will accept up to one less than half of the course credits required for the M.S. degree program in transfer from other MCEE member institutions provided that (1) the student earned a grade of at least 3.0 or equivalent in the related courses; (2) the credits were not earned in research or thesis courses; and (3) the total number of credits accepted in transfer from MCEE member institutions or from other institutions does not exceed one less than half of the credits required.

Master's seminar requirement: First year graduate students are required to attend 7 seminars from the graduate seminar series.

Proficiency requirement: Regardless of whether admission status is regular or provisional, students whose undergraduate degree is not in Electrical or Computer Engineering must demonstrate proficiency in 3 out of the following courses: ECE 302 (Electronic Circuits); ECE 305 (Electromagnetic Field and Waves); ECE 313 (Control Systems); ECE 366 (Signal Processing). Proficiency is shown by (i) enrolling for the class and receiving a passing grade, or (ii) taking the class final examination along with the students enrolled in the class at the regularly scheduled final examination time and passing the exam, or (iii) having a substantially identical class on record on an official transcript or (iv) take the Ph.D. Qualifying Exams that correspond to these courses. The Qualifying Exams correspond to the courses in parentheses; Microelectronics and VLSI (ECE 302), Electromagnetics (ECE 305), Control (ECE 313), Signal Processing and Communications (ECE 366).

Master's degree program plan filing: The student's program of study must be approved before the student completes 6 credits of graduate work in order for the student to continue to enroll in the master's degree program. For any independent study or selected topics course that is included in the student's approved program of study, the subject material and the instructor must be specified. The academic adviser for each student will assist the student in planning a program satisfactory to the needs of the student. Changes in program plans may be made only with the approval of the adviser, the Associate Chairperson for Research and Graduate Studies, and the Associate Dean for Research and Graduate Studies. Please see Appendix 3 for guidance on planning a program in various areas of graduate study in electrical engineering. Also,

please see Appendix 4 for worksheets that you may use in planning your program, and an illustration of a Master's Degree Program Plan. When you are ready to file your program, provide the information to the graduate secretary. A form will be generated to be signed first by you, then your advisor, and then the other signatories.

Modifications to the master's program: With reference to the student's approved program of study, none of the following types of changes will be approved:

1. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass-No Grade, or Credit-No Credit).
2. Adding or deleting a course for which grading was postponed by the use of the DF-Deferred marker.
3. Adding or deleting a course which the student dropped after the middle of the semester and for which "W" or "N" or "0.0" was designated.
4. Adding or deleting a course during the final semester of enrollment in the master's degree program.

Appendix 4 also illustrates the change of a particular Master's degree program.

Residency requirement for the Master's degree: At least 9 credits must be taken in residence.

Time limit for the Master's degree: The time limit for the completion of the requirements for the master's degree is five calendar years from the date of enrollment in the first course included for degree certification.

Grade point average for graduation: The Engineering College requires a minimum GPA of 3.0 for courses on the approved Master's degree program plan. The University requires a minimum total GPA of 3.0. The total GPA may be different than the program GPA if classes were taken that was not listed on the program. For DF-Deferred grades, the required work must be completed and a grade reported within 6 months with the option of a single six-month extension. If the required work is not completed within the time limit, the DF will become U-Unfinished and will be changed to DF/U under the numerical and Pass-No Grade (P-N) grading systems, and to DF/NC under the Credit-No Credit (CR-NC) system. This rule does not apply to graduate thesis or dissertation work.

Master's degree examinations: The student is required to pass an oral examination in defense of the thesis. Section 6 of the handbook describes this examination.

Master's thesis distribution: The thesis, an abstract of the thesis, and an abstract title page must be prepared in accordance with the specifications in The Formatting Guide-Master's Theses and Doctoral Dissertations, a handbook that is available, along with a packet of required forms relating to the thesis from the Office of the Graduate School. An unbound, original copy with abstract is

provided to the Office of the Graduate School. A hardbound copy, made from the original unbound manuscript submitted to the Office of the Graduate School, must be provided to both the M.S. thesis advisor and to the Department. Arrangements for the delivery of the copies shall be made when the original manuscript is submitted to the Office of the Graduate School. The Department will not be able to certify the degree if the hard copy is not received.

One microfilm copy of the dissertation will be deposited in the University Library and will be available on interlibrary loan. The abstract will be published in Master's Abstracts which will announce the availability of the thesis in film form.

Final semester: The diploma card must be completed by the student when registering for the final semester. All deferred grades must be cleared at least two weeks before the end of the final semester.

### **3.4 Requirements for the Master's degree, Plan B**

The Plan B master's degree consists of prescribed course work and a final evaluation. All requirements from Plan A apply to plan B except that (1) a minimum of 18 credits must be in courses at the 800-900 level and (2) those requirements specifically related to the thesis do not apply. The final evaluation is performed by the student's academic advisor and the Department's Associate Chairperson for Research and Graduate Studies.

### **3.5 Requirements for the Doctor of Philosophy degree**

The Doctor of Philosophy degree consists of prescribed course work, a qualifying examination, a comprehensive examination, research, a dissertation, and a final oral examination. Each student working toward a Doctor of Philosophy must conduct research upon which a dissertation that makes a significant contribution to knowledge is prepared and published. The research is to be under the direction of and acceptable to the doctoral guidance committee.

Doctoral guidance committee: Each graduate student admitted to the doctoral program has the responsibility to form a guidance committee with the approval and the assistance of the Department chairperson or designated representative. Section 5 of the handbook provides additional information regarding the guidance committee.

Course credit requirements: The doctoral program must minimally include thirty-six (36) semester credits, in addition to ECE 999 and exclusive of any independent study credits, beyond the B.S. degree in 800/900 level courses. A minimum of three (3) of these credits must be taken outside the Engineering College in areas such as Mathematics, Statistics, and Physics. All such courses must be taken under the numerical grading system, with the exception that up to three (3) Master's thesis credits may be applied to the Ph.D. course requirement.

Courses will be prescribed by the guidance committee to ensure that the student has a comprehensive knowledge of a major research field and related subjects. The required courses will depend upon the student's academic background in relation to the selected research specialization.

Doctoral dissertation credit requirements: In addition to the minimal 36 credits prescribed by the guidance committee, the student must register for and successfully complete 24 credits of doctoral dissertation research, course number ECE 999.

Transfer credits: The guidance committee may, in considering the Department doctoral course credit requirements, count courses taken in graduate programs at other institutions of similar quality if they are appropriate to the students program and provided they were completed within the time limits approved for earning the degree. Such courses must be documented for Department records and the documentation must be included with the doctoral plan of study. It is not necessary to formally transfer such credits and they are not listed on the College of Engineering Doctoral Degree Program Plan. Instead, such courses are listed on the Department's Supplement to the Report of the Guidance Committee. This supplement should also list graduate courses taken in other graduate degree programs at MSU that the guidance committee wishes to count toward the Department's doctoral course credit requirements. Such courses must have been taken while enrolled in a graduate degree program or while dual-enrolled in a graduate program and an undergraduate program. Courses taken in an undergraduate program should not be listed on the Supplementary Report. An undergraduate program is one in which the degree granted is a bachelor's degree, regardless of the number of credits or years.

Seminar requirement: First year graduate students are required to attend 7 seminars from the graduate seminar series.

Proficiency requirement: Students whose undergraduate degree is not in Electrical or Computer Engineering must demonstrate proficiency in 3 out of the following courses: ECE 302, ECE 305, ECE 313, ECE 366.

Doctoral program filing: The student's program of study shall be submitted as a Guidance Committee report for approval to the Department and to the Dean by no later than the end of the student's second semester of enrollment in the doctoral program. For any selected topics course that is included in the student's program of study the subject material and the instructor must be specified. The student's program of study must be approved in order for the student to continue to enroll in the doctoral degree program beyond the second semester.

Please see Appendix 5 for worksheets that you may use in planning your doctoral program, and an illustration of a Doctoral Degree Program Plan. When you are ready to file your program, provide the information to the graduate secretary. A form will be generated to be signed first by you, then your guidance committee, and then the other signatories.

Modifications to the doctoral program: With reference to the student's approved program of study, none of the following types of changes will be approved:

1. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass–No Grade, or Credit–No Credit).
2. Adding or deleting a course for which grading was postponed by the use of the DF–Deferred marker.
3. Adding or deleting a course which the student dropped after the middle of the semester and for which "W" or "N" or "0.0" was designated.
4. Adding or deleting a course during the final semester of enrollment in the doctoral degree program.

Doctoral residency requirement: One year of residence on campus after first enrollment for doctoral credit is required to permit the student to work with and under the direction of the faculty, and to engage in independent and cooperative research utilizing University facilities. A year of residence will be made up of two consecutive semesters, involving the completion of at least six credits of graduate work each semester.

Doctoral degree time limit: The comprehensive examination must be passed within five years and all the remaining requirements for the degree must be completed within eight years from the time when a student begins the first class at MSU that appears on his or her doctoral program of study. Application for extensions of the eight-year period of time toward the degree must be submitted by the Department for approval by the Dean of Engineering and by the Dean of the Graduate School. Upon approval of the extension, doctoral comprehensive examinations must be passed again.

Grade point average for graduation: The Engineering College requires a minimum GPA of 3.0 for courses on the approved doctoral degree program. The University requires a minimum total GPA of 3.0. The total GPA may be different than the program GPA if classes were taken that was not listed on the program. For DF-Deferred grades, the required work must be completed and a grade reported within 6 months with the option of a single six-month extension. If the required work is not completed within the time limit, the DF will become U-Unfinished and will be changed to DF/U under the numerical and Pass-No Grade (P-N) grading systems, and to DF/NC under the Credit-No Credit (CR-NC) system. This rule does not apply to graduate thesis or dissertation work.

Doctoral examinations: The student is required to pass the qualifying examination, the comprehensive examination, and a final oral examination in defense of the dissertation. Please see section 2 of this handbook for further information regarding the qualifying and comprehensive examinations, and section 6 for information regarding the dissertation defense.

Doctoral dissertation distribution: The dissertation, an abstract, and an abstract title page must be prepared in accordance with the specifications in The Formatting Guide-Master's Theses and Doctoral Dissertations, a handbook that is available, along with a packet of required forms relating to the dissertation from the Office of the Graduate School. An unbound, original copy with abstract is provided to the Office of the Graduate School. A hardbound copy, made from the original unbound manuscript submitted to the Office of the Graduate School, must be provided to both the guidance committee chairperson and to the Department. Arrangements for the delivery of the copies shall be made when the original manuscript is submitted to the Office of the Graduate School. The Department will not be able to certify the degree if the hard copy is not received.

One microfilm copy of the dissertation will be deposited in the University Library and will be available for interlibrary loan. The abstract will be published in Dissertation Abstracts which will announce the availability of the dissertation in film form.

Final semester: The diploma card must be completed by the student when registering for the final semester. All deferred grades must be cleared at least two weeks before the end of the final semester.

### **3.6 Readmission process**

Students whose enrollment at Michigan State University is interrupted for more than three consecutive terms (including summer); whose last enrollment ended with recess or dismissal; or who have completed their academic program, need to submit an application for readmission. This application should be submitted at least one month prior to the beginning of the term in which the student expects to resume studies. For further information, see the Office of the Registrar's web site:

<http://www.reg.msu.edu/StuForms/ReAdmission/ReAdmission.asp>

Readmission to the electrical engineering graduate program may depend on the availability of an academic advisor and the availability of a graduate assistantship. Thus, a student seeking readmission is advised to first check with the academic advisor regarding these matters.

### **3.7 Full-time status**

In order to be considered full time for academic purposes, a student must carry the minimum number of credits per semester as defined below:

Master's level: 9 credits,

Doctoral level: 6 credits,

Graduate–Professional level: 12 credits.

All graduate assistants are classified as full time students during the semester (s)

of their appointments as long as they are enrolled for the minimum required credits for the assistantship (see Section 10.5 of this Handbook). Full time status for doctoral students is defined as a minimum of 1 credit for those students who:

1. Have successfully completed all comprehensive exams and are actively engaged in dissertation research; or
2. Are doing department-approved off-campus fieldwork related to preparation of their dissertation.



## **4. SELECTION OF THESIS/DISSERTATION ADVISOR**

Graduate education, research, and creative activities take place within a community of scholars where constructive relationships between graduate students and their advisors and mentors are essential for the promotion of excellence in graduate education and for adherence to the highest standards of scholarship, ethics, and professional integrity. Initiation and successful completion of independent research requires early and continued advice and oversight by a faculty advisor.

For students in the electrical engineering doctoral graduate program, the faculty advisor is the guidance committee chairperson as well as the academic advisor. That faculty member is the 'major professor' for the student. For students in the electrical engineering master's graduate program, plan A, the faculty advisor is the student's academic advisor and thesis advisor. For plan B master's students, the faculty advisor is the academic advisor. Faculty advisors must be members of the electrical engineering faculty, appointed at the level of Assistant Professor or higher.

### **4.1 Time line for selection of a permanent faculty advisor**

All students in the electrical engineering graduate program must have a faculty advisor. Master's degree students are to have selected a permanent advisor prior to the completion of 6 credits in their master's degree program. Doctoral students must select a permanent advisor prior to the completion of two semesters. Many students will have selected an advisor prior to beginning their program. The Department's Associate Chairperson for Graduate Studies will assign a temporary advisor to students for whom this is not the case.

### **4.2 Advisor selection process**

Students who are admitted to the electrical engineering graduation program with a research assistantship that is provided by a particular faculty member will have that faculty member as their academic advisor and thesis/dissertation advisor. Other students may be admitted with a graduate assistantship or fellowship that is from general funds or third-party funds and not explicitly tied to a particular faculty member. In those cases, the selection of an advisor is based on mutual research interests. It is also generally based on intent of the faculty member to provide financial support after the general funds support ends, assuming availability of funds and satisfactory performance. The Department's policy is to establish that there is indeed such interest from at least one faculty member prior to sending a letter of admission. When more than one faculty member has expressed interest in serving as academic advisor to a student who was admitted with an assistantship or fellowship from general funds or third parties, the

student should select an advisor within the time frame described in the previous section. Appendices 2 and 3 provide information about the research interests of faculty and examples of current research projects.

#### **4.3 Roles and responsibilities of the thesis/dissertation advisor**

The role of the advisor includes the following:

- Ensuring that graduate students receive information about requirements and policies of the graduate program.
- Advising graduate students on developing a program plan, including appropriate course work, research or creative activity, and on available resources.
- Advising graduate students on the selection of a thesis or dissertation topic with realistic prospects for successful completion within an appropriate time frame and on the formation of a guidance committee.
- Providing training and oversight in creative activities, research rigor, theoretical and technical aspects of the thesis or dissertation research, and in professional integrity.
- Encouraging graduate students to stay abreast of the literature and cutting-edge ideas in the field.
- Helping graduate students to develop professional skills in writing reports, papers, and grant proposals, making professional presentations, establishing professional networks, interviewing, and evaluating manuscripts and papers.
- Providing regular feedback on the progress of graduate students toward degree completion, including feedback on research or creative activities, course work, and teaching, and constructive criticism if the progress does not meet expectations.
- Helping graduate students develop into successful professionals and colleagues, including encouraging students to participate and disseminate results of research or creative activities in the appropriate scholarly or public forums.
- Facilitating career development, including advising graduate students on appropriate job and career options, as well as on the preparation of application materials for appropriate fellowship, scholarship, and other relevant opportunities.
- Writing letters of reference for appropriate fellowship, scholarship, award, and job opportunities.
- Providing for supervision and advising of graduate students when the faculty advisor is on leave or extended absence.

#### **4.4 Roles and responsibilities of the student**

The student also has responsibilities in the advisor/student relationship. These include the following:

- Learning and adhering to University and academic unit rules, procedures, and policies applicable to graduate study and research or creative activities, including those outlined in the publications Academic Programs, Graduate Student Rights and Responsibilities, and Academic Freedom for Students at MSU.
- Meeting University and academic unit requirements for degree completion.
- Forming a guidance committee that meets University requirements as well as requirements that are outlined in the Graduate Handbook of the academic unit.
- Following disciplinary and scholarly codes of ethics in course work, thesis or dissertation research, and in creative activities.
- Practicing uncompromising honesty and integrity according to University and federal guidelines in collecting and maintaining data
- Seeking regulatory approval for research in the early stages of thesis or dissertation work where applicable.
- Keeping the faculty advisor and guidance committee apprised on a regular basis of the progress toward completion of the thesis or dissertation.

#### **4.5 Change of advisors**

Once a permanent thesis/dissertation advisor is selected, it is unusual to change advisors. However, if a situation arises where a change seems imperative, the student should consult with the Department's Associate Chairperson for Graduate Studies who will facilitate changes of faculty advisor.

## **5. FORMATION OF THE GUIDANCE COMMITTEE**

Each graduate student admitted to the doctoral program has the responsibility to form a guidance committee with the approval and the assistance of the Department chairperson or designated representative. The guidance committee will consist of at least four Michigan State University regular faculty, including the committee chairperson. The committee chairperson is also the student's academic advisor. At least two members of the guidance committee shall be from the Electrical and Computer Engineering Department and at least one member shall be from a different academic Department at Michigan State University. Please see the MSU Academic Programs publication for additional information regarding definition of regular faculty.

The responsibilities of the guidance committee include the following.

- Advising graduate students on course work, research, or creative activities.
- Providing at least annually feedback and guidance concerning progress toward the degree.
- Administering the comprehensive exams and the final oral exam in a fair and professional manner.
- Reviewing the thesis or dissertation in a timely, constructive and critical manner.
- Committee chairpersons on leave shall provide for the necessary guidance of their advisees during their absence.

## **6. THESIS/DISSERTATION DEFENSE AND FINAL ORAL EXAMINATION**

### **6.1 Nature and scope of the thesis/dissertation**

The final master's or doctoral examination is the culmination of a student's graduate education and training and reflects not only the accomplishments of the graduate student but also on the quality of the graduate program. An approved thesis/dissertation that is accepted by the graduate school becomes a single-author publication and contributes to the body of knowledge of electrical engineering. The Department keeps a library of all master's and doctoral theses accepted by the Department. Those from recent years are stored in the Departmental conference room. Please see the graduate secretary if you wish to check out a copy for short-term borrowing.

### **6.2 Examination regulations and format**

The graduate student will present the results of the thesis/dissertation in a seminar open to the community. The student should arrange a suitable examination date after consulting with the thesis advisor and members of the examination committee. The student should also arrange for a suitable room in which to hold the seminar by consulting with the office staff of the Electrical and Computer Engineering Department. This should be done in communication with the Department graduate secretary, who will arrange for announcement of the upcoming defense. The announcement should be formatted according to a standard template (see Appendix 9) and should include a title, student's and advisor's name and affiliation, dissertation abstract and a list of creative works that resulted from the student's doctoral research.

For both the master's degree candidate and doctoral candidate, the following regulations apply.

- The final oral examination must be scheduled for a date not earlier than two weeks after the dissertation and abstract have been submitted to the chairperson of the guidance committee, other guidance committee members, and any appointed examiner.
- The student must be registered during the semester in which the final oral examination is taken.
- The dissertation and the student's performance on the final oral examinations must be approved by a positive vote of at least three-fourths of the voting examiners and with not more than one dissenting vote from among the Michigan State University regular faculty members of the guidance committee.

For both the master's degree candidate and doctoral candidate, the following format is typical. The examining committee members may or may not choose to meet before the exam to discuss the procedure. The candidate presents the results in seminar fashion and responds to questions and comments from those in attendance. After the general audience has had opportunity to raise questions and comments, they are excused from the room and the defense continues with only the examining committee. At the end of the examination, the student is asked to step out of the room, and the examining committee members each indicate in writing a pass or fail grade. The student is then asked to enter the room to receive the result of the final examination. A summary report of the examination result is submitted to the Dean of Engineering and the Chairperson of the Department.

### **6.3 Master's degree examining committee**

The examination committee consists of at least three Michigan State University regular faculty members, at least two of whom must be on the faculty of the Department of Electrical and Computer Engineering. The committee is selected by the thesis advisor and student with the approval of the Department's Associate Chairperson for Research and Graduate Studies. One member of the committee must be the thesis advisor. Other interested faculty members may attend the examination without vote.

### **6.4 Doctor of Philosophy degree examining committee**

The doctoral final oral examination committee consists of the student's guidance committee. According to University policy, at the discretion of the Dean of Engineering, the guidance committee may be augmented by one appointed faculty member. Other interested faculty members may attend the examination without vote.

## **7. DEPARTMENT POLICIES: ACADEMIC PERFORMANCE**

### **7.1 Academic standards for the Master of Science program**

Grades: The student must earn a grade of 2.0 or higher in each course in the approved program of study. The student must repeat any course for which the grade earned was below 2.0.

Cumulative Grade Point Average: The student must maintain a cumulative grade–point average of at least 3.00 in the courses in the approved program of study.

Probational Status: A student is placed on probational status if the student's cumulative grade–point average for the courses in the approved program of study is below 3.00. A student in probational status is not allowed to enroll in any course the primary focus of which is independent study.

Retention in and dismissal from the Master's Program:

- Should a student's cumulative grade–point average fall below 3.00 after having completed 16 or more credits in courses in the approved program of study, the student may be enrolled in probational status in the master's degree program for one additional semester. If at the end of the additional semester the student's cumulative grade–point average is 3.00 or higher, the student may continue to enroll in the master's degree program. If at the end of the additional semester the student's cumulative grade–point average is still below 3.00, the student will be dismissed from the program.
- Each student's academic progress and professional potential are evaluated by March 15 of each year. A student who in the judgment of the faculty is making satisfactory academic progress and has professional potential may continue to enroll in the master's degree program, provided the grade point average is within the acceptable range as previously described. A student who in the judgment of the faculty is not making satisfactory academic progress or lacks professional potential will be dismissed from the program.

### **7.2 Academic standards for the Doctor of Philosophy program**

Grades. The student must earn a grade of 2.0 or higher in each course in the approved guidance committee report, including collateral courses and courses accepted in transfer or used as part of the minimal number of doctoral credits. The student must repeat any course for which the grade earned was below 2.0.

Cumulative Grade Point Average: The student must maintain a cumulative grade–point average of at least 3.00 in the courses in the approved guidance committee.

Probational Status: A student is placed on probational status if the student's cumulative grade–point average for the courses in the approved program of study is below 3.00. A student in probational status is not allowed to enroll in any course the primary focus of which is independent study.

Retention in and dismissal from the Doctoral Program:

- Should a student's cumulative grade–point average fall below 3.00 after having completed half of the courses in the approved guidance committee report, the student may be enrolled in probational status in the doctoral degree program for one additional semester. If at the end of the additional semester the student's cumulative grade–point average is 3.00 or higher, the student may continue to enroll in the doctoral degree program. If at the end of the additional semester the student's cumulative grade–point average is still below 3.00, the student will be dismissed from the program.
- Should a student accumulate more than 3 deferred grades in courses other than those courses the primary focus of which is independent study, the student may be enrolled on probational status in the doctoral program for one additional semester. If at the end of the additional semester the student has no more than 3 deferred grades, the student may continue to enroll in the doctoral degree program. If at the end of the additional semester, the student still has more than 3 deferred grades, the student will be dismissed from the program.
- Each student's academic progress and professional potential are evaluated by March 15 of each year. A student who in the judgment of the faculty is making satisfactory academic progress and has professional potential may continue to enroll in the doctoral degree program, provided the grade point average and number of courses with deferred grades is within the acceptable range as previously described. A student who in the judgment of the faculty is not making satisfactory academic progress or lacks professional potential will be dismissed from the program.

Note that the grading procedure for the qualifying examinations and the comprehensive examinations, and the policy for repeats of this examination are described in section 2 of this handbook.

### **7.3 Student records**

The Department maintains an academic record for students that are kept on file until 5 years after graduation. Graduate students have the right to inspect any of their own educational records, barring confidential letters of recommendation, including their official transcript. Students also shall have the right to inspect reports and evaluations of his or her academic performance.

A typical inventory of the Department record is as follows.



- College of Engineering Master's Plans and Doctoral Plans.
- Guidance Committee reports.
- Results of qualifying examinations, comprehensive examinations, and final oral examinations.
- Grade reports from the Office of the Registrar.
- Annual evaluation forms.
- Other forms filed by the student or on behalf of the student.
- Items from the student's application for admission, including transcripts, test scores, and reference letters.

The Department maintains a separate personnel file for teaching assistants, as prescribed by the GEU/MSU contract. The Department also maintains a separate personnel file for research assistants.

## **8. DEPARTMENT POLICIES: INTEGRITY AND SAFETY IN RESEARCH AND CREATIVE ACTIVITIES**

### **8.1 The MSU perspective**

Each graduate student shall have the document Guidelines for Integrity in Research and Creative Ideas. See Section 1.5 for access to this document. The conduct of research and creative activities by faculty, staff, and students is central to the mission of Michigan State University and is an institutional priority. Faculty, staff, and students work in a rich and competitive environment for the common purpose of learning, creating new knowledge, and disseminating information and ideas for the benefit of their peers and the general public. The stature and reputation of MSU as a research university are based on the commitment of its faculty, staff, and students to excellence in scholarly and creative activities and to the highest standards of professional integrity.

As a partner in scholarly endeavors, MSU is committed to creating an environment that promotes ethical conduct and integrity in research and creative activities. Innovative ideas and advances in research and creative activities have the potential to generate professional and public recognition and, in some instances, commercial interest and financial gain. In rare cases, such benefits may become motivating factors to violate professional ethics. Pressures to publish, to obtain research grants, or to complete academic requirements may also lead to an erosion of professional integrity.

Breaches in professional ethics range from questionable research practices to misconduct. The primary responsibility for adhering to professional standards lies with the individual scholar. It is, however, also the responsibility of advisors and of the disciplinary community at large. Passive acceptance of improper practices lowers inhibitions to violate professional ethics.

Integrity in research and creative activities is based not only on sound disciplinary practice but also on a commitment to basic personal values such as fairness, equity, honesty, and respect. These guidelines are intended to promote high professional standards by everyone — faculty, staff, and students alike.

For further information and training, graduate students are encouraged to participate in the Responsible Conduct of Research workshop series, sponsored by the Office of the Vice President for Research and Graduate Studies and by the Graduate Dean. Information on this series is available at the graduate school web site: <http://www.msu.edu/user/gradschl/>

### **8.2 Key principles**

Integrity in research and creative activities embodies a range of practices that includes:

- Honesty in proposing, performing, and reporting research.
- Recognition of prior work.
- Confidentiality in peer review.
- Disclosure of potential conflicts of interest.
- Compliance with institutional and sponsor requirements.
- Protection of human subjects and humane care of animals in the conduct of research.
- Collegiality in scholarly interactions and sharing.
- Adherence to fair and open relationships between senior scholars and their co-workers.

Honesty in proposing, performing, and reporting research: The foundation underlying all research is uncompromising honesty in presenting one's own ideas in research proposals, in performing one's research, and in reporting one's data. Detailed and accurate records of primary data must be kept as unalterable documentation of one's research and must be available for scrutiny and critique. It is expected that researchers will always be truthful and explicit in disclosing what was done, how it was done, and what results were obtained. To this end, research aims, methods, and outcomes must be described in sufficient detail such that others can judge the quality of what is reported and can reproduce the data. Results from valid observations and tests that run counter to expectations must be reported along with supportive data.

Recognition of prior work: Research proposals, original research, and creative endeavors often build on one's own work and also on the work of others. Both published and unpublished work must always be properly credited. Reporting the work of others as if it were one's own is plagiarism. Graduate advisors and members of guidance committees have a unique role in guiding the independent research and creative activities of students. Information learned through private discussions or committee meetings should be respected as proprietary and accorded the same protection granted to information obtained in any peer review process.

Confidentiality in peer review: Critical and impartial review by respected disciplinary peers is the foundation for important decisions in the evaluation of internal and external funding requests, allocation of resources, publication of research results, granting of awards, and in other scholarly decisions. The peer-review process involves the sharing of information for scholarly assessment on behalf of the larger disciplinary community. The integrity of this process depends on confidentiality until the information is released to the public. Therefore, the contents of research proposals, of manuscripts submitted for publication, and of other scholarly documents under review should be considered privileged information not to be shared with others, including students and staff, without explicit permission by the authority requesting the review. Ideas and results

learned through the peer-review process should not be made use of prior to their presentation in a public forum or their release through publication.

Disclosure of potential conflicts of interest: There is real or perceived conflict of interest when a researcher has material or personal interest that could compromise the integrity of the scholarship. It is, therefore, imperative that potential conflicts of interest be considered and acted upon appropriately by the researcher. Some federal sponsors require the University to implement formal conflict of interest policies. It is the responsibility of all researchers to be aware of and comply with such requirements.

Compliance with institutional and sponsor requirements: Investigators are granted broad freedoms in making decisions concerning their research. These decisions are, however, still guided, and in some cases limited, by the laws, regulations, and procedures that have been established by the University and sponsors of research to protect the integrity of the research process and the uses of the information developed for the common good. Although the legal agreement underlying the funding of a sponsored project is a matter between the sponsor and the University, the primary responsibility for management of a sponsored project rests with the principal investigator and his or her academic unit.

Protection of human subjects and humane care of animals in the conduct of research: Research techniques should not violate established professional ethics or federal and state requirements pertaining to the health, safety, privacy, and protection of human beings, or to the welfare of animal subjects. Whereas it is the responsibility of faculty to assist students and staff in complying with such requirements, it is the responsibility of all researchers to be aware of and to comply with such requirements.

Collegiality in scholarly interactions and sharing of resources: Collegiality in scholarly interactions, including open communications and sharing of resources, facilitates progress in research and creative activities for the good of the community. At the same time, it has to be understood that scholars who first report important findings are both recognized for their discovery and afforded intellectual property rights that permit discretion in the use and sharing of their discoveries and inventions. Balancing openness and protecting the intellectual property rights of individuals and the institution will always be a challenge for the community. Once the results of research or creative activities have been published or otherwise communicated to the public, scholars are expected to share materials and information on methodologies with their colleagues according to the tradition of their discipline.

Faculty advisors have a particular responsibility to respect and protect the intellectual property rights of their advisees. A clear understanding must be reached during the course of the project on who will be entitled to continue what part of the overall research program after the advisee leaves for an independent position. Faculty advisors should also strive to protect junior scholars from

abuses by others who have gained knowledge of the junior scholar's results during the mentoring process, for example, as members of guidance committees.

Adherence to fair and open relationships between senior scholars and their coworkers: The relationship between senior scholars and their coworkers should be based on mutual respect, trust, honesty, fairness in the assignment of effort and credit, open communications, and accountability. The principles that will be used to establish authorship and ordering of authors on presentations of results must be communicated early and clearly to all coworkers. These principles should be determined objectively according to the standards of the discipline, with the understanding that such standards may not be the same as those used to assign credit for contributions to intellectual property. It is the responsibility of the faculty to protect the freedom to publish results of research and creative activities. The University has affirmed the right of its scholars for first publication except for "exigencies of national defense". It is also the responsibility of the faculty to recognize and balance their dual roles as investigators and advisors in interacting with graduate students of their group, especially when a student's efforts do not contribute directly to the completion of his or her degree requirements.

### **8.3 Misconduct in research and creative activities**

Federal and University policies define misconduct to include fabrication (making up data and recording or reporting them), falsification (manipulating research materials, equipment or processes, or changing or omitting data such that the research is not accurately represented in the record), and plagiarism (appropriation of another person's ideas, processes, results, or words without giving appropriate credit). Serious or continuing non-compliance with government regulations pertaining to research may constitute misconduct as well. University policy also defines retaliation against whistle blowers as misconduct. Misconduct does not include honest errors or honest differences of opinion in the interpretation or judgment of data.

The University views misconduct to be the most egregious violation of standards of integrity and as grounds for disciplinary action, including the termination of employment of faculty and staff, dismissal of students, and revocation of degrees. It is the responsibility of faculty, staff, and students alike to understand the University's policy on misconduct in research and creative activities, to report perceived acts of misconduct of which they have direct knowledge to the University Intellectual Integrity Officer, and to protect the rights and privacy of individuals making such reports in good faith.

## **8.4 Research involving human subjects**

The University Committee on Research Involving Human Subjects (UCRIHS) is an Institutional Review Board (IRB). Federal regulations and University policy require that all research projects involving human subjects and materials of human origin be reviewed and approved by an IRB before initiation. Research is defined as "a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge". The "generalizable knowledge" criteria may include developing publications/papers, theses/dissertations, making public presentations, etc. A human subject of research is a) a living individual from whom an investigator obtains data by interaction or intervention or b) identifiable private information.

All research involving human subjects and/or data collected from living human subjects (including preexisting data) is subject to UCRIHS review. Instructions for applying for approval are available at the following web site:

<http://www.humanresearch.msu.edu/>.

## **8.5 Research involving animals**

The use of vertebrate animals in research, teaching, and outreach activities is subject to state and federal laws and guidelines. University policy specifies that: all vertebrate animals under University care (that is, involved in projects under the aegis or sponsorship of the University) will be treated humanely; prior to their inception, all vertebrate animal projects receive approval by the All University Committee on Animal Use and Care (AUCAUC); Michigan State University (MSU) will comply with state and federal regulations regarding vertebrate animal use and care.

Responsibility for assuring compliance with state and federal regulations belongs to the Vice President for Research and Graduate Studies. The Vice President has designated the Assistant Vice President for Research and Graduate Studies to be the "Institutional Official" as defined in federal regulations.

The AUCAUC works closely with the Institutional Official, and has responsibility and authority under federal law for specific actions.

University Laboratory Animal Resources (ULAR), which reports to the Vice President for Research and Graduate Studies, provides a comprehensive program of animal care for all laboratory animal colonies, as well as training for researchers. ULAR also participates in developing institutional policies designed to insure humane treatment of vertebrate animals and to assist investigators in maintaining high quality care of animals used in MSU projects.

An animal use form (AUF) must be submitted to the AUCAUC for review prior to the start of the project, regardless of the source of funding for the project. The AUF can be obtained from the AUCAUC office; the completed form will include descriptions of experimental protocols, plans for animal care, available facilities,

and any other matters relevant to the project. Some granting agencies require review and approval of the AUF before a grant application will be processed. An agency-approved grant will not be accepted by the Board of Trustees, nor will an account number be assigned, unless the AUF has been approved by the AUCAUC. For an animal use application form contact: Candy Flynn at 432-4151, email flynnnc@msu.edu

## **8.6 Office of Radiation Chemical and Biological Safety (ORCBS)**

The use of hazardous materials in research, teaching, and outreach activities is subject to state and federal laws and guidelines. The Vice President for Research and Graduate Studies has been assigned responsibility to see that appropriate practices are followed where hazardous materials are involved, to maintain a safe environment for campus personnel, to protect the surrounding community, and to assure that MSU meets its obligations under the law.

Oversight of activities involving hazardous substances is provided by the ORCBS. ORCBS is assisted by faculty committees in the areas of radiation safety, chemical safety, and biological safety. The Radiation Safety Committee has responsibility and authority under federal law for specific actions.

It is University policy that faculty members and principal investigators (PIs) are responsible for the day-to-day safety and well-being of all personnel engaged in activities under their aegis. Administrative officers, and ORCBS, are responsible for making available to faculty information needed to maintain a safe working environment, for providing safety training, for keeping project directors informed about changes in regulations, and for assaying laboratories and work areas for radiation, chemical, or biological hazards.

All individuals who work with hazardous substances must accept shared responsibility for operating in a safe manner once they have been informed (a) about the extent of risk and (b) about safe procedures that should be followed.

The ORCBS provides live and on-line training classes throughout the year to educate the employees and students of Michigan State University on safe work practices. Completion of these courses by MSU personnel ensures that the university is fulfilling local, state and federal requirements in radiation, chemical, biological, hazardous waste, and environmental safety.

Your training requirements will depend on your specific job duties. Some general guidelines are listed below:

- Required for **all laboratory employees** engaging in the use of hazardous chemicals (and supervisors of the employees): Chemical Hygiene and Laboratory Safety; Hazardous Waste Refresher (required annually after completion of Chemical Hygiene & Laboratory Safety course) and Security Awareness.

- Required for **all employees working with radiation**: Radiation Safety Initial; Radiation Safety Refresher (required annually following completion of the Radiation Safety Initial course).
- Required for **all employees with a reasonable anticipated risk of exposure to bloodborne pathogens/human blood/bodily fluids**: Bloodborne Pathogen Initial; Bloodborne Pathogen Refresher; (required annually following completion of the Bloodborne Pathogen Initial course)

If you would like assistance determining which courses you should complete, please contact the ORCBS at 355-0153.



## **9. STUDENT CONDUCT AND CONFLICT RESOLUTION**

### **9.1 Student conduct**

The University expects student conduct and behavior to reflect qualities of good citizenship. The out-of-classroom activities of Michigan State University students should reflect favorably upon the institution and should indicate the personal integrity of the individual. See Spartan Life: Student Handbook and Resource Guide for specific policies, ordinances and regulations that define some of the relevant University expectations.

### **9.2 Conflict resolution**

Student's rights and responsibilities, including grievance procedures, are detailed in the document: Academic Freedom for Students at Michigan State University. Procedures more specifically designed for graduate students are to be found in the publication Graduate Student Rights and Responsibilities. In the event of grievances, procedures outlined in these documents shall be followed.

Conflicts involving a graduate student may be handled informally or, at the request of a party or parties, formally. Both parties should attempt to resolve problems in informal, direct discussions. If the problem remains unresolved, then the Chairperson of the Department and/or the Ombudsman should be consulted. If still aggrieved, a student may then submit a formal, written grievance for consideration by a Department hearing board. The hearing board shall be composed of the Department Chairperson or designee and equal numbers of faculty and graduate students selected by their respective groups in accordance with Department Bylaws. If the Department Chairperson is involved in the case, neither the Chairperson nor the designee may serve on the hearing board.

Either party to a grievance may appeal the decision of the Department hearing board to the Engineering College hearing board. All appeals must be in writing.

## **10. WORK RELATED POLICIES**

### **10.1 Overview**

This section provides current and prospective graduate students in electrical engineering with information regarding work related policies, information regarding financial support, and information regarding tuition and fees. Financial support for graduate students takes different forms and might include one or more of the following: a fellowship, a research assistantship, or a teaching assistantship. Specific awards change with time to reflect changes in tuition, fees, and the general cost of living. The Department of Electrical and Computer Engineering has a number of fellowships and assistantships available for qualified graduate students. Applicants for admission into either the M.S. (with thesis) or Ph.D. programs in electrical engineering are automatically considered for financial support. Admission is linked to the availability of such support.

Sources of financial support include the University itself, the College of Engineering, the Department of Electrical and Computer Engineering, and off-campus organizations in both the public and private sector. Qualifications for receiving specific types of aid vary depending upon the funding source. Some financial aid packages place certain restrictions/responsibilities upon the recipient. For example, a half-time graduate assistantship would require the recipient to perform an average of twenty (20) hours per week of duties in service on the average to the University during the appointment period.

Many financial-support packages require that the student make satisfactory progress toward completing a degree of study. The Department's criteria for satisfactory academic progress includes: course credits completed per semester, the nature of these courses, the grades received, successful completion of required qualifying/comprehensive examinations, and progress in completing M.S. or Ph.D. dissertation research. In addition to satisfactory progress toward completing the degree, continuation of graduate support would depend upon the following: the recipient has performed the assigned duties satisfactorily; past level of support and total number of semesters of support; the availability of funds to continue the current level of financial assistance; the needs of the Department for the particular services for which the recipient is qualified to perform. When resources for financial aid are limited and the demand of aid exceeds the amount of funds available, continuation of financial aid for an individual will depend upon merit relative to others requesting aid and the needs of the Department to fulfill its overall mission of teaching, research and outreach.

## **10.2 Teaching assistantship selection criteria**

Essentially all TA positions in ECE are reserved for new, incoming students. However, from time to time there is an unexpected vacancy in one course (usually for one semester only). To fill such a position the graduate secretary keeps a list of students who may be interested in a TA position. This list is kept at the ECE Department Office (2120 EB) and is recreated every semester. If there is an opening it will happen very close to the beginning of the semester, leaving no time to post specific advertisements.

Please contact the graduate secretary if you wish to be added to the list. Preference is given to PhD students with experience in the course that has an opening. Academic performance and specific experience in the topic at hand are used if more than one student is available.

In considering the assignment of ECE Teaching Assistantships, the Graduate Admissions, Recruitment and Financial Aid Committee has adopted a set of criteria as a guideline for selecting applicants for TA positions. These are intended to support the Department's teaching mission and research mission. The ranked criteria for TA appointment decisions are:

- Those students to whom the Department has a prior commitment to provide support, such as students who have received recruitment offers upon admission or who have received a multi-year support offer.
- Ph.D. students actively involved in research and do not have a research assistantship, fellowship, or like support. This would be considered an unusual and time limited situation because the normal expectation is that a doctoral student would have a research assistantship or other non-TA support. Appointments would usually be limited to no more than a year unless there were extenuating circumstances.
- M.S. students doing a thesis who do not have a research assistantship, fellowship, or like support. Appointments would usually be limited to no more than a year unless there were extenuating circumstances.

Academic performance and qualifications to teach a particular course will also be considered in TA appointment decisions. For international students for whom English is not the official language of their home country, a minimum fluency in spoken English must be demonstrated by any one of the following:

- A score of 50 on the Test of Spoken English (TSE) given by the Educational Testing Service,
- A score of 50 or higher on the SPEAK given by the English Language Center at Michigan State University,

- Taking English 097 (The ITA Speaking and Listening Class at Michigan State University) and getting a score of 50 or higher on the ITA Oral Interview (ITAOI). The English Language Center at Michigan State University gives the ITAOI.

### **10.3 Research assistantship selection criteria**

Research assistants are generally selected from among the graduate student body and from among qualified applicants by individual faculty members. Research assistants are often selected to work on a specific research project or projects for which the faculty member has funding. Often, but not necessarily always, the work is related to the thesis work of the student. Renewal of research assistantships is based on satisfactory performance and availability of funds.

### **10.4 The Graduate Employees Union (GEU)**

Teaching Assistants should be aware of their rights and responsibilities under the current version of the contract between MSU and the GEU. The Department will provide you with a copy of this agreement if you are appointed as a TA. You may also obtain the agreement, and other information about the GEU, at the web site <http://www.hr.msu.edu/documents/contracts/GEU2011-2015.pdf>.

### **10.5 University graduate assistantship policies**

Graduate Assistants (including research assistants and teaching assistants) are available only to graduate students who are making satisfactory progress toward their degrees, including maintaining at least a 3.00 grade point average. Graduate assistants are appointed on a quarter-time, half-time, or three-quarter time basis. The academic year encompasses two appointment periods – August 16 – December 31 and January 1 – May 15. Summer appointments cover the period from May 16 – August 15. During each appointment period a graduate assistant's duties to the University require an average of:

- 10 hours per week for a quarter-time stipend.
- 20 hours per week for a half-time stipend.
- 30 hours per week for a three-quarter time stipend.

The student is expected to be available during the appointment period. Any absences, including for attendance of professional meetings, must be arranged with the supervising faculty member and the Department.

Graduate assistants must be registered each semester in which they hold assistantships. For quarter-time appointments, the minimum enrollment is 6 credits for master's degree students and 3 credits for doctoral students prior to

completion of the comprehensive examination (including credits in 899 and 999) and the maximum enrollment is 16 credits (excluding credits in 899 or 999). For half-time appointments, the minimum enrollment is 6 credits for master's degree students and 3 credits for doctoral students prior to completion of the comprehensive examination (including credits in 899 and 999) and the maximum enrollment is 12 credits (excluding credits in 899 or 999). For three-quarter time appointments, the minimum enrollment is 6 credits for master's degree students and 3 credits for doctoral students prior to completion of the comprehensive examination.(including credits in 899 and 999) and the maximum enrollment is 12 credits (excluding credits in 899 or 999). The minimum enrollment for doctoral students who have successfully completed all comprehensive examinations is 1 credit for all graduate assistantship levels.

International students should also be aware of minimum credit enrollments to satisfy visa requirements. The MSU Office of International Students and Scholars is an important resource of information in this regard.

### **10.6 Graduate assistants covered By the GEU**

For GEU covered assistantships, please see the current MSU/GEU agreement for information regarding stipends, tuition and fee benefits, and health insurance coverage.

### **10.7 Graduate assistants not covered by the GEU**

The information listed below is subject to yearly change. Please consult The Graduate School home page for the latest information at

<http://www.grad.msu.edu>.

Stipends: Checks are distributed on the fifteenth of the month. For Fall semester 2004, the monthly stipend for a level-one assistantships is approximately \$1,430. For a level-two assistantship (requires a year of assistantship experience) the monthly stipend is approximately \$1,630. Level 3 assistantship levels are currently the same as for level 2.

Tuition and fee benefits: Even though the graduate student does not enroll for 10 credits or more, benefits include the following:

1. Tuition waiver in the amount of 9 credits for Fall semester, 9 credits for Spring semester, and four credits for summer session. The tuition waiver will be provided during the period of the assistantship, to a maximum of 22 credits per year.
2. Exemption from out-of-state resident tuition. This exemption applies to a summer session that precedes or follows an appointment for an entire academic year, regardless of whether the student was previously enrolled at MSU. If the student does not have a signed graduate assistantship form

before registering for summer session, he or she will pay out-of-state resident course fees and tuition. Upon receiving a copy of the appointment form for the entire academic year through the middle of the semester of the subsequent fall semester, the Office of the Registrar will refund the full amount of out-of-state tuition that the student paid for the summer session.

3. Matriculation and infrastructure/technology support fees are waived.

Health Insurance: Graduate assistants (domestic and international) are automatically enrolled in a health insurance plan, the premium of which is paid by the University. The plan provides the following coverage:

- Fall appointment only: coverage from August 15 to February 14 of the following year.
- Fall and spring appointments—coverage from August 15 to August 14 of the following year.
- Spring appointment only—coverage from January 1 to August 14.
- Summer appointment only—coverage from May 15 to August 14. Enrolled students may also insure their eligible spouse and/or dependent children (residing with the insured).

For questions regarding coverage, enrollment or premium payment, contact The Chickering Group directly at 1-800-859-8452.

For questions concerning waiver processing or general information, contact the MSU Benefits office at (517) 353-4434 (Nisbet Building), East Lansing, MI 48823 and on the web: <http://www.hr.msu.edu/index.asp>; for the MSU Benefits Office and [www.chickering.com](http://www.chickering.com) for the Chickering Group.

### **10.8 Externally funded fellowships and in-state tuition status.**

Receipt of externally funded fellowships by students who have written their own grant applications and worth at least \$20,000 (direct costs) now makes the students eligible for in-state tuition rate. The in-state tuition rate applies only to the semesters during which the student is supported by the fellowship. This policy applies only to grants funded through a competitive process by a US institution/agency/foundation. Funds obtained through non-competitive processes (e.g., need-based fellowships) or from international sources do not qualify the students for in-state tuition rates. For more information contact Melissa Del Rio ([mdelrio@msu.edu](mailto:mdelrio@msu.edu)) in 110 Linton Hall.

### **10.9 Use of Department facilities and supplies**

Graduate students in the electrical engineering programs are provided with a campus mailbox in the Engineering Building. They have access to computer systems under the supervision of the Division of Engineering Computing Services (DECS), and server storage and email accounts, also via DECS. Most graduate students find it well worth their while to purchase their own personal computer, to supplement the services provided by DECS. Graduate assistants are provided with office space and telephone access for local and campus calls. Copy machines are available in the Engineering Library with a customary charge per page. Teaching assistants may have material copied that is required for their teaching duties by the office copying machine without charge, up to a per-semester allotment.

### **10.10 Fees and rates**

For current information regarding fees and rates associated with enrolling in the Graduate Programs in Electrical Engineering, please see the "Online Calculator" for Tuition, Fees, and Housing Calculator at the web site <http://www.ctlr.msu.edu/COSTudentAccounts/TuitionCalculator.aspx>.

Note that a half-time teaching assistantship or research assistantship includes coverage of tuition for 9 credits as well as a monthly stipend.

### **10.11 Outside work for pay**

Outside work for pay must be within guidelines established by the University and College. The University guidelines for outside work for pay for graduate assistants are that the student must continue to make adequate progress toward the degree. If the Department judges that the student is not making adequate progress that is a basis for terminating the assistantship after a reasonable warning period.

## **11. UNIVERSITY RESOURCES**

### **11.1 The University**

Michigan State University has been advancing knowledge and transforming lives through innovative teaching, research, and outreach for 150 years. It is known worldwide as a major public university with global reach and extraordinary impact. It's a 14 degree-granting college and affiliated private law school offer 200 programs of study. They attract scholars worldwide who are interested in combining education with practical problem solving.

Students from all 83 counties in Michigan, all 50 states in the United States, and about 125 other countries are represented in the student body of 46,045 students (Fall Semester, 2007). There are approximately 4,500 faculty and academic staff, and approximately 6,000 support staff employees. Library resources include a research collection of approximately 4.8 million volumes housed in the main library and nine branch libraries across campus. More than 500 registered student organizations include honoraries; professional organizations and professional fraternities and sororities; recreational and athletic groups; and international, racial/ethnic, religious, academic interest area, political, social service, volunteer, and media organizations.

In Fall Semester, 2007, there were 8,596 students in graduate and professional programs of study. The Graduate School at MSU provides programs that serve all graduate students, including a variety of free workshops throughout the year. The Council of Graduate Students represents all registered MSU graduate and graduate-professional students. The Graduate Employee's Union represents Teaching Assistants.

### **11.2 The College**

Michigan State University's Engineering College offers graduate programs through 6 academic Departments: Agricultural Engineering, Chemical Engineering and Materials Science, Civil and Environmental Engineering, Computer Science and Engineering, Electrical and Computer Engineering, and Mechanical Engineering. The college houses many research centers and laboratories, which vigorously promote the interdisciplinary collaboration of its faculty members with each other, and with other university Departments, other universities, and the general public.

A \$34.5 million addition and renovation in 1989 provided 167,000 square feet of space for laboratories, classrooms, offices, and the engineering library. The Engineering Building, constructed in 1962, underwent a \$14-million, 46,000square-foot addition in 1997, accommodating the Herbert H. and Grace A. Dow Institute for Materials Research, one of the premier facilities in the world for the study of composite materials. Other facilities include the Engineering Facility



at the MSU Research Complex; the Jolly Road Research Facility; and the Automotive Research Experiment Station located in the Hulett Road Research Facility.

### **11.3 The Department**

The electrical engineering graduate program has approximately 180 students, of which about two-thirds are doctoral students and one-third master's students. The graduate students work in close relationship with the approximately 40 faculty in the Electrical and Computer Engineering Department in a strong and growing research program. Typically, over 30 graduate courses are offered in an academic year, with an average class size of 15 students. We invite you to visit the Department's home web page at <http://www.egr.msu.edu/ece/> to learn more about the Department, including the current events.

### **11.4 The campus**

Campus cultural and other special centers include the Wharton Center for Performing Arts, Kresge Art Museum, MSU Museum, Kellogg Center, Abrams Planetarium, WKAR-AM/FM public radio, and WKAR public television. Sports devotees can follow the performance of any of the 25 men's and women's intercollegiate teams on campus. Those wishing to participate in athletics can take advantage of any of the many facilities available. These include gymnasiums for basketball and racquet sports, an indoor ice-skating rink, five swimming pools, a number of outdoor tennis courts, and two 18-hole golf courses. The intramural sports program is one of the largest in the nation.

The campus has been called "an academic park" and the beautiful gardens and landscaping are testimony to many generations of careful stewardship. The 5,200 acres, located three miles east of Michigan's Capitol in Lansing, represent a unique blend of the traditional and the innovative and is adjacent to its college town, East Lansing. The Red Cedar River traverses the campus and offers opportunities for lively activities such as canoe races or quiet reflection for those who wish to walk or study along its tree-lined shores.

### **11.5 The Lansing community**

The greater Lansing area, with a population of approximately a half-million, boasts a fine symphony orchestra which performs at the Wharton Center; several dance and theater groups, art galleries; the state capitol building, museums, state and local libraries; an arboretum, a zoo, a variety of parks, and a number of restaurants to suit most pocketbooks and tastes.

Graduate students in need of a change of scene can take the train to Chicago from East Lansing or drive an hour or two to Ann Arbor, Grand Rapids, or

Detroit. In addition, day or weekend jaunts can be made to such attractions as Greenfield Village and the Henry Ford Museum, the Irish Hills, the Kellogg Biological Station, numerous National and State Forests in both the lower and upper peninsulas, Lake Michigan and Lake Huron beaches and parks, and Mackinac Island. Recreational activities in Michigan are highlighted by water sports in the summer months and skiing in winter.

## **Appendix 1 – Topic Content of the Subject Areas for Part A of the Ph.D. Qualifying Examination (revised: 10/10)**

### Circuit Fundamentals

Fundamental laws and theorems associated with electric circuits, including Kirchhoff's current law and Kirchhoff's voltage law, power balance, Thevenin's theorem and Norton's theorem; circuit analysis methods and techniques, including node-voltage analysis, mesh-current analysis, and superposition; two-port networks and transfer functions; DC analysis; AC analysis including sinusoidal steady state phasors, s-domain representation including high-pass, low-pass, and band-pass filters; transient analysis including first-order and second-order circuits; current-voltage characteristics of elements including independent and dependent sources, resistors, capacitors, inductors, transistors, and operational amplifiers; analysis of circuits consisting of interconnections of such devices.

#### Typical Textbooks:

Roland E. Thomas and Albert J. Rosa, Analysis and Design of Linear Circuits, Wiley, 2009, 6th ed., ISBN: 978-0-470-38330-8.  
[Giorgio Rizzoni, Principles and Applications of Electrical Engineering](#), McGraw-Hill, 2007, 5th ed., ISBN: 978-0072962987.

### Digital Logic Fundamentals

Boolean algebra; Boolean minimization using Karnaugh maps; fundamental logic gates; combinational logic design; operation and structure of standard logic components (e.g., decoders, encoders, multiplexers, registers, counters, binary adders); programmable logic devices (PLAs); flip-flops and latches; sequential system fundamentals and state machines; synthesis of synchronous sequential circuits; timing diagrams; arithmetic operations and circuits (addition, subtraction); memory elements and systems (ROM, RAM).

#### Typical Textbooks:

Stephen Brown and Zvonko Vranesic, Fundamentals of Digital Logic with VHDL Design, McGraw-Hill, 2008, 3rd ed., ISBN: 9780077221430.

Daniel Pack and Steven Barrett, Microcontroller Theory and Applications: HC12 and S12, Prentice Hall, 2008, 2nd ed., ISBN: 978-0-13-615205-7.

## Computer Architecture

Computer abstractions and technology, performance, power, and cost analysis, instruction set architecture, relationship between high-level, assembly, and machine language programs, computer arithmetic, processor datapath and control, pipelining, memory hierarchy, storage and input-output systems, interrupts and exceptions, multicores, multiprocessors, and clusters.

### Typical Textbooks:

David A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, Elsevier, 2009, 4th ed., ISBN-13: 978-0123744937.

John L. Hennessy and David A. Patterson, Computer Architecture: A Quantitative Approach, Elsevier, 2007, 4th ed., ISBN-13: 978-0123704900.

## Computer Networks

Fundamentals of computer networks; physical layer protocols including analog and digital transmission, circuit switched network, datagram oriented networks; transmission media; data link control layer protocols including basic principles of error detection (CRC) and correction (FEC) , stop-and-wait protocols, sliding window protocols, medium access control, contention-based protocols, Ethernet variants, IEEE 802.3; network layer including routing algorithms, internetworking, congestion control mechanisms, IP protocol; transport layer protocols including connection management, UDP and TCP.

### Typical Textbooks:

Andrew S. Tanenbaum, Computer Networks, Prentice Hall, 2002, 4th ed., ISBN: 0130661023.

Alberto Leon-Garcia and Indra Widjaja, Communication Networks: Fundamental Concepts and Key Architectures, McGraw Hill, 2003, 2nd ed., ISBN: 007246352X.

## Control

Mathematical models of systems; feedback control system characteristics and performance; sensitivity; time and frequency responses; Laplace transform analysis of time-invariant systems; stability; root locus method; Nyquist criterion and Bode plots; design and compensation.

### Typical Textbooks:

Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Prentice Hall, 2011, ISBN-13: 978-0-13-602458-3.

Norman S. Nise, Control Systems Engineering, Wiley, 2008, ISBN-13: 978-0471-79475-2.

Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Prentice Hall, 2009, ISBN-13 978-0-13-601969-5.

## Electromagnetics

Electrostatics; magnetostatics; solution to static field equations for simple source systems and geometries; capacitance and inductance; power and energy; Maxwell's equations and their application in simple systems; applications of Faraday's law; wave equations for electric and magnetic fields; plane Electromagnetic (EM) waves; reflection and transmission of EM waves; electromagnetic radiation, radiation from linear antennas; parallel plate waveguides; Telegrapher's equations; transients on transmission lines; sinusoidal steady-state transmission lines; Smith chart; impedance matching.

### Typical Textbooks:

Aziz S. Inan and Umran S. Inan, Engineering Electromagnetics, Addison Wesley, 2004, ISBN: 0805344233.

David K. Cheng, Field and Wave Electromagnetics, Addison Wesley, 1989, 2nd ed., ISBN: 0201128195.

Nannapaneni Narayana Rao, Elements of Engineering Electromagnetics, (Illinois ECE Series), Prentice Hall, 2004, 6th ed., ISBN: 0131139614.

## Electronic Devices

Semiconductor basics: crystallinity and orientation; introductory quantum mechanics; energy density of states; energy bands; charge carrier densities; conductivity and mobility; equilibrium properties; non-equilibrium properties and charge carrier transport; quantum wells. Diode basics: p-n and metal-semiconductor junctions; biasing and switching behavior. Transistor basics: Bipolar junction transistors; MOSFETs; CMOS; biasing of transistors; equivalent circuits of transistors.

### Typical Textbooks:

Ben G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Prentice Hall, 6th ed., 2006, ISBN-10: 013149726X, ISBN-13: 978-0131497269.

Donald A. Neamen, Semiconductor Physics and Devices, McGraw Hill, 3rd ed., 2006, ISBN: 0070617120.

## Microelectronic Circuits and VLSI

Fundamental operation, current-voltage characteristics, and large and small signal models of electronic devices such as diodes, bipolar junction transistors, and field effect transistors; operation, design, and analysis of circuits composed of semiconductor devices; design and analysis of basic analog circuits including single stage amplifiers, differential amplifiers, current mirrors and the effects of noise and high frequency; fundamentals of digital integrated circuit design; design and analysis of CMOS digital logic gates, combinational and sequential logic circuits, and memory cells and arrays; performance and reliability considerations in integrated circuit design; layout rules and physical design of CMOS mixed signal circuits.

### Typical Textbooks:

D.A. Johns and K. Martin, Analog Integrated Circuit Design, Wiley, 1997, ISBN 0-471-14448-7.

John P. Uyemura, Introduction to VLSI Circuits and Systems, Wiley, 2002, ISBN 0471127043.

## Power Systems

Per unit system; delta and wye connections; single and three phase power; induction and synchronous machine models; operation and application of motors and generators, single and three phase transformer models; single and three phase uncontrolled and controlled rectifiers; single and three phase inverters; choppers; dc to dc converters; variable voltage and frequency drives; losses and efficiency; load flow input and output, symmetrical components.

### Typical Textbooks:

A.E. Fitzgerald, Charles Kingsley, and Stephen D. Umans, Electric Machinery, McGraw Hill, 2003, 6th ed., ISBN: 0073660094 or 0071121935.

Muhammad H Rashid, Power Electronics: Circuits, Devices, and Applications, Prentice Hall, 2003, 3rd edition, ISBN: 0131011405.

Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics: Converters, Applications, and Design, Wiley, 2002, 3<sup>rd</sup> ed., ISBN-10: 0471226939.

## Signal Processing & Communication

Analog and discrete signal models; sampling theory; linear, time-invariant (LTI) system analysis in the time domain; impulse response and convolution; Laplace transform and its use in analyzing LTI systems; Fourier series; Fourier transform and frequency response; discrete-time Fourier transform; z-transform and its use in analyzing discrete-time systems; amplitude and frequency modulation; basic probability, random variables, expected value, variance, covariance, some basic probability density functions.

### Typical Textbooks:

Alan S. Willsky and Alan V. Oppenheim, Signals and Systems, Prentice Hall, 2000, 2nd ed., ISBN: 0136511759.

Ashok Ambardar, Analog and Digital Signal Processing, Brooks/Cole, 1999, ISBN: 053495409X.

William H. Tranter and Rodger E. Ziemer, Principles of Communication: Systems, Modulation and Noise, Wiley, 2001, 5th ed., ISBN: 0471392537.

## Appendix 2 – Faculty Listing

Listed below are the Electrical and Computer Engineering Department faculty and some important information about them. The citations contain faculty names followed by their current academic ranks, highest degrees awarded, universities where they earned the degrees, year the degrees were earned, a brief description of their current research interests, their telephone numbers, and their email addresses. Please also visit the Department web site at [www.egr.msu.edu/ece/](http://www.egr.msu.edu/ece/) for information about the Department's adjunct faculty.

**Aslam, Dean M.** – Associate Professor; Ph.D., Aachen, 1983. Diamond microsensors, field emitters and MEMS, diamond FED, SiC thermistors. [517-353-6329, [aslam@egr.msu.edu](mailto:aslam@egr.msu.edu)]

**Asmussen, Jes** – Richard M. Hong Professor and University Distinguished Professor; Ph.D. Wisconsin, 1967. Plasmas, microwave processing of materials, ion and electrothermal thrusters. [517-355-4620, [asmussen@egr.msu.edu](mailto:asmussen@egr.msu.edu)]

**Aviyente, Selin** – Associate Professor; Ph.D., University of Michigan, 2002. Signal processing, nonstationary signal analysis methods, application of information theory to analysis and classification, algorithms for computation of time-frequency distributions, applications of signal processing on biological signals. [517-355-7649, [aviyente@egr.msu.edu](mailto:aviyente@egr.msu.edu)]

**Ayres, Virginia** – Associate Professor; Ph.D., Purdue University, 1985. Electronic/structural properties and biocompatibility of nanostructures, growth mechanisms of carbon nanostructures, amorphous tetrahedral carbon, diamond, and silicon nanowires, site-specific scanning probe microscopy, and nanomanipulation. [517-355-5236, [ayresv@egr.msu.edu](mailto:ayresv@egr.msu.edu)]

**Balasubramaniam, Shanker** – Professor; Ph.D., Pennsylvania State University, 1993. Applied electromagnetics, fast algorithms for transient and frequency domain solutions, computational techniques in materials, and optics. [517-432-8136, [bshanker@egr.msu.edu](mailto:bshanker@egr.msu.edu)]

**Biswas, Subir** – Associate Professor; Ph.D., University of Cambridge, 1994. Wireless data networking, low-power network protocols and algorithms, sensor networks, wireless Ad-Hoc networks, QoS-middleware for resource-constrained networks, control-plane network security, architecture and protocols for targeted content delivery in mobile networks. [517-432-4614, [sbiswas@egr.msu.edu](mailto:sbiswas@egr.msu.edu)]



**Chahal, Prem** - Assistant Professor; Ph.D., Georgia Institute of Technology, 1999. Terahertz (THz) and Millimeter-Wave Electronics, IR Sensors, Microsystems Packaging, RF-MEMS, BioMEMS, and Flex Electronics. [517-355-0248, [chahal@msu.edu](mailto:chahal@msu.edu)]

**Chakrabartty, Shantanu** – Assistant Professor; Ph.D., The Johns Hopkins University, 2004. Ultra-low power mixed signal VLSI systems, adaptation and learning on silicon, biometric hardware, speech recognition interfaces, and non-linear signal processing. [517-432-5679, [shantanu@egr.msu.edu](mailto:shantanu@egr.msu.edu)]

**Choi, Jongeun** - Assistant Professor, Ph.D., University of California at Berkeley, 2006. Adaptive, learning, distributed and robust control, with applications to unsupervised competitive learning algorithms, self-organizing systems, distributed coordination algorithms for autonomous vehicles, multiple robust controllers and micro-electromechanical systems (MEMS). [517-432-3164, [jchoi@egr.msu.edu](mailto:jchoi@egr.msu.edu)]

**Deller, John R.** – Professor; Ph.D., University of Michigan, 1979. Speech processing, system identification and adaptive filtering, and biomedical applications of signal processing. [517-353-8840, [deller@egr.msu.edu](mailto:deller@egr.msu.edu)]

**Dong, Lixin** - Assistant Professor; Ph.D., Nagoya University, 2003. Nanorobotics, nanoelectromechanical systems (NEMS), mechatronics, mechanochemistry, and nanobioedical devices. [517-353-3918, [ldong@egr.msu.edu](mailto:ldong@egr.msu.edu)]

**Goodman, Erik** – Professor; Ph.D., University of Michigan, 1972. Genetic algorithms, design optimization, manufacturing optimization, environmentally conscious manufacturing. [517-355-6453, [goodman@egr.msu.edu](mailto:goodman@egr.msu.edu)]

**Grotjohn, Timothy** – Chair and Professor; Ph.D., Purdue University, 1986. Plasma-assisted materials processing, plasma source design, modeling, diagnostics and applications, microwave plasmas, miniature and micro plasmas, computational modeling of plasma. [517-353-8906 & 517-432-7127, [grotjohn@egr.msu.edu](mailto:grotjohn@egr.msu.edu)]

**Hogan, Timothy** – Professor; Ph.D., Northwestern University, 1996. Charged transport measurements, pulse laser deposition of new electronic materials. [517-432-3176, [hogant@egr.msu.edu](mailto:hogant@egr.msu.edu)]

**Jain, Anil** – University Distinguished Professor; Ph.D., Ohio State University, 1973. Pattern recognition, computer vision and biometric authentication. [517-355-9282, [jain@cse.msu.edu](mailto:jain@cse.msu.edu)]

**Kempel, Leo** – Professor; Ph.D., University of Michigan, 1994. Electromagnetic theory; computational electromagnetics; finite element methods; large-scale scientific computing; antenna analysis and design; scattering. [517-353-9944, [kempel@egr.msu.edu](mailto:kempel@egr.msu.edu)]

**Khalil, Hassan** – Associate Chair for Undergraduate Studies and University Distinguished Professor; Ph.D., University of Illinois, 1978. Nonlinear control, singular perturbation methods, robust control. [517-355-6689, [khalil@egr.msu.edu](mailto:khalil@egr.msu.edu)]

**Li, Tongtong** – Associate Professor; Ph.D., Auburn University, 2000. Digital communications and signal processing, wireless and wireline communications, information theory, coding and decoding, networking. [517-355-7688, [tongli@egr.msu.edu](mailto:tongli@egr.msu.edu)]

**Li, Wen** - Assistant Professor; Ph.D., California Institute of Technology, 2008. MEMS/NEMS technologies and systems, micro sensors and actuators, biomimetic devices and systems, microfluidic and lab-on-chip systems, and microsystem integration and packaging technologies. [517-353-7832, [wenli@egr.msu.edu](mailto:wenli@egr.msu.edu)]

**Mahapatra, Nihar** – Associate Professor; Ph.D., University of Minnesota, 1996. Parallel and high-performance computing, computer architecture and VLSI, and dependability. [517-432-4617, [nrm@egr.msu.edu](mailto:nrm@egr.msu.edu)]

**Mason, Andrew** – Associate Professor; Ph.D., University of Michigan, 2000. Mixed-signal integrated circuits, microsystems, microsensors, and micro-electro-mechanical systems (MEMS). [517-355-6502, [mason@egr.msu.edu](mailto:mason@egr.msu.edu)]

**McGough, Robert** – Associate Professor; Ph.D., University of Michigan, 1995. Research interests include medical ultrasound for thermal therapy, diagnostic imaging, and heat-mediated drug delivery. [517-432-3333, [mcgough@egr.msu.edu](mailto:mcgough@egr.msu.edu)]

**Mitra, Joydeep** - Associate Professor; Ph.D., Texas A&M University, 1997. Power system reliability and security, and distributed and renewable energy resource planning. [517-353-8528, [mitraj@msu.edu](mailto:mitraj@msu.edu)]

**Mukkamala, Ramakrishna** – Associate Professor; Ph.D., Massachusetts Institute of Technology, 2000. Biomedical signal processing and identification, modeling of physiologic systems, and cardiovascular physiology. [517-353-3120, [rama@egr.msu.edu](mailto:rama@egr.msu.edu)]

**Oweiss, Karim** – Associate Professor; Ph.D., University of Michigan, 2002. Statistical array signal processing, Multiresolution analysis and wavelet coding, information theory, biosignal analysis in Microsystems, applications in neurophysiology and bioengineering. [517-432-8137, [koweiss@egr.msu.edu](mailto:koweiss@egr.msu.edu)]

**Peng, Fang Zheng** – Professor; Ph.D., Nagaoka University of Technology, Japan, 1990. Power electronics, motor drives, hybrid electric vehicles, renewable energy interface systems. [517-432-3331, [fzpeng@egr.msu.edu](mailto:fzpeng@egr.msu.edu)]

**Pierre, Percy** – Emeritus Professor; Ph.D., Johns Hopkins University, 1967. Communications theory, stochastic processes, signal detection and estimation. [517-432-5148, [pierre@egr.msu.edu](mailto:pierre@egr.msu.edu)]

**Radha, Hayder** – Professor and Associate Chair for Research and Graduate Studies; Ph.D., Columbia University, 1993. Coding and communications, image and video compression, image processing, multimedia communications over packet networks, video coding and communications over the Internet and wireless networks, modeling and analysis of the stochastic behavior of communication networks, wavelet, sub-band, and Multiresolution coding. [517-432-9958, [radha@egr.msu.edu](mailto:radha@egr.msu.edu)]

**Reinhard, Donnie** – Professor; Ph.D., MIT, 1973. Electronic and optical materials and devices, low-temperature deposition and development of optical quality diamond, optical applications of thin-film diamond, application and synthesis of microstructures. [517-355-5214, [reinhard@egr.msu.edu](mailto:reinhard@egr.msu.edu)]

**Ren, Jian** – Assistant Professor; Ph.D. Xidian University, 1994. Computer engineering, communication networks, network security, cryptographic algorithms and protocols, error control coding. [517-353-4379, [renjian@egr.msu.edu](mailto:renjian@egr.msu.edu)]

**Rothwell, Edward** – Professor; Ph.D., Michigan State University, 1985. Transient electromagnetic scattering, antennas, radar target identification, electromagnetic theory. [517-355-5231, [rothwell@egr.msu.edu](mailto:rothwell@egr.msu.edu)]

**Salem, Fathi** – Professor; Ph.D., U.C. Berkeley, 1983. Neural Networks and learning algorithms, microelectronic VLSI and MEMS neural systems, adaptive nonlinear processing and control, optimization and optimal control. [517-355-7695, [salem@egr.msu.edu](mailto:salem@egr.msu.edu)]

**Shanblatt, Michael** – Professor; Ph.D., University of Pittsburgh, 1980. Computer engineering, VLSI architectures for enhanced control, neural networks, VLSI design methodologies. [517-353-7249, [mas@egr.msu.edu](mailto:mas@egr.msu.edu)]

**Strangas, Elias** – Associate Professor; Ph.D., University of Pittsburgh, 1980. Electrical machinery, finite-element methods for electromagnetic fields, electrical drives, power electronics. [517-353-3517, [strangas@egr.msu.edu](mailto:strangas@egr.msu.edu)]

**Tan, Xiaobo** – Assistant Professor; Ph.D., University of Maryland, 2002. Modeling and control of smart materials and micro-electromechanical systems, control with limited communication, distributed control of networked systems, computational micromagnetics and numerical integrated of dynamical systems on manifolds. [517-432-5671, [xtan@egr.msu.edu](mailto:xtan@egr.msu.edu)]

**Udpa, Lalita** – Professor; Ph.D., Colorado State University, 1986. Electromagnetic fields and waves, computational methods for electromagnetics, pattern recognition and digital signal processing. [517-355-9261, [udpal@egr.msu.edu](mailto:udpal@egr.msu.edu)]

**Udpa, Satish** – Dean and Professor; Ph.D., Colorado State University, 1983. Nondestructive evaluation, electromagnetics, signal processing, pattern recognition, and numerical analysis. [517-355-5114, [udpa@egr.msu.edu](mailto:udpa@egr.msu.edu)]

**Wang, Bingsen** – Assistant Professor; Ph.D., University of Wisconsin – Madison, 2006. [517-355-0911, [mailto:bingsen@msu.edu](mailto:mailto:bingsen@msu.edu)]

**Wei, Guowei** – Associate Professor; Ph.D., University of British Columbia, 1996. Numerical analysis; scientific computing; wavelet-collection based local spectral methods. Kinetic/statistic theory; nonlinear dynamics; pattern formation, PDE based image processing; pattern recognition; biomedical images. [517-353-4689, [wei@math.msu.edu](mailto:wei@math.msu.edu)]

**Wierzba, Gregory** – Associate Professor; Ph.D., University of Wisconsin, 1978. Analog electronics, macromodeling, computer-aided design, active filters. [517-355-5225, [wierzba@egr.msu.edu](mailto:wierzba@egr.msu.edu)]

**Xi, Ning** – Professor; D.Sc., Washington University (St. Louis), 1993. Control theory and applications, robotics system planning and control, manufacturing automation, network communication, microsystem design and applications, and real-time system design and implementation. [517-432-1925, [xin@egr.msu.edu](mailto:xin@egr.msu.edu)]

### **Appendix 3 – Department areas of specialization and sample programs.**

This portion of the handbook is intended to provide assistance in planning both the research and course portions of your graduate study experience. Graduate study in our Department is organized into three broad areas. Within these broad areas are sub-areas of specialization as shown below.

- Computer Engineering
  - Computer Networks
  - Computer Architecture
  - VLSI/Microelectronics
- Electrosiences
  - Electromagnetics
  - Electronic Materials and Devices
- Systems
  - Biomedical
  - Power
  - Signal Processing and Communications
  - Control and Robotics

For each of the above, an overview of research is provided as well as specific examples of research opportunities in the Electrical and Computer Engineering Department. These provide guidance regarding choice of a thesis topic. You are encouraged to contact faculty within the area to obtain more information about specific research projects as well as additional research opportunities that may not be listed in these pages.

Regarding course selection, graduate plans of study are individualized, depending on your interests. Each graduate student should establish a plan early in the program of study – at least by the end of the first semester of study for Master's students and by the end of the first year of study for Doctoral students.

The following Master Degree Sample Programs are 'plan A' programs, i.e. with thesis, that have been organized to be completed in 4 semesters, including summer, starting in a Fall Semester of the Academic year. You may use these example plans to help you in designing your own course plan, modifying them as is appropriate to your interests. The sample plans ensure that all core requirements are met, as well as other University, College, and Department minimum requirements as described in detail elsewhere in this handbook. As you plan your course of study, please consult with your academic advisor to design your specific program that will also meet those degree requirements.

A doctoral program plan of study depends strongly on the dissertation topic, and is prescribed for the candidate by the student's doctoral guidance committee. Thus, the establishment of your doctoral guidance committee will precede the selection of a doctoral course plan.

## **BIOMEDICAL ENGINEERING (BME) AREA**

### **Introduction**

Biomedical Engineering is presently one of the fastest growing application areas in engineering. As the population ages and health issues are increasingly emphasized, the demand for better medical systems designed by biomedical engineers will increase. The demand for biomedical engineers will continue to grow as new technologies emerge for the prevention, diagnosis, and treatment of disease. Biomedical research in the Department of Electrical and Computer Engineering (ECE) at MSU combines expertise in life sciences, signal processing, image processing, system modeling and analysis, sensors, electromagnetics, and acoustics. These strengths are employed in three biomedical research areas (Thermal Therapy and Medical Imaging, Cardiovascular Signal Processing, and Neural Systems Engineering). Faculty members with research interests in biomedical engineering include Professors Chakrabartty, Deller, McGough, Mukkamala, and Oweiss.

### **Research Areas**

*Thermal Therapy and Medical Imaging:* Thermal therapy research in ECE at MSU involves the modeling, construction, and evaluation of external phased array devices for noninvasive cancer therapy. Ultrasound phased arrays and electromagnetic phased arrays are phased and focused within tumor targets to directly destroy cancer cells, to sensitize cancer cells to the effects of ionizing radiation, and to preferentially deliver drugs to the tumor while sparing normal healthy tissues. Both ultrasound and electromagnetic phased arrays are fabricated within the ECE Department, along with the associated digital control circuitry and analog power amplifiers. The phase array devices are modeled with analytical and numerical methods, including finite difference methods, finite element methods, and integral methods. Beamforming is performed on each of these arrays for the purpose of patient treatment planning, which optimizes the temperature distribution in tumors as predicted by the bio-heat transfer equation (BHTE).

Medical imaging research is also strongly supported within the ECE Department. Ongoing research projects with PET/CT, diagnostic ultrasound, and MRI are presently supported as part of an interdisciplinary collaborative effort to improve diagnostic and therapeutic procedures in the human clinic.

*Cardiovascular Signal Processing:* This multi-disciplinary research area is focused on the development and evaluation of novel technologies for the monitoring and diagnosis of cardiovascular disease. The technologies are developed based on advanced signal processing methods in combination with physiologic knowledge

so as to maximize the amount of information that can be garnered from clinical measurements (e.g., ECGs and blood pressure waveforms). These technologies are validated in both simulation studies and experimental studies involving animal models as well as human subjects. Current research in this area is aimed at, for example, the non-invasive monitoring of cardiac output, cardiac contractility, autonomic nervous control of the circulation, and electrical anomalies of the heart.

*Neural Systems Engineering:* The main research focus in Neural Systems Engineering is to develop and enhance the signal processing technology in microimplantable devices in the nervous system. This is achieved through the development of advanced algorithms for signal processing and neural information decoding from theory to hardware design needed to embed them onto small BioMEMS featuring real-time, sustainable functionality in living brain tissue. This requires interdisciplinary research that combines expertise in signal processing, information theory, software development, custom hardware design, clinical neurophysiology and computational neuroscience.



**M.S. Degree in Electrical Engineering  
with Emphasis on Biomedical Engineering Option I:  
A Sample Program of Study for Bioacoustics and Bioelectromagnetics**

Fall Semester (FS)	Credits
1. ECE 835 Electromagnetic Fields and Waves I	(3)
2. Select one of the following:	(3)
ECE 802 Medical Imaging	
ECE 802 Acoustics	
3. Select one of the following:	(3)
MTH 850 Numerical Analysis I	
MTH 841 Boundary Value Problems I	
MTH 848 Ordinary Differential Equations	
Spring Semester (SS)	
1. Select one of the following:	(3)
ECE 836 Electromagnetic Fields and Waves II	
ECE 802 Canonical Problems in Advanced Electromagnetics	
2. Select one of the following:	(3)
MTH 851 Numerical Analysis II	
MTH 842 Boundary Value Problems II	
MTH 849 Partial Differential Equations	
3. Select one of the following:	(3)
ECE 802 Image Processing	
ECE 802 Wavelets and Time-Frequency Analysis	
Summer Semester (US)	
1. ECE 899 Masters thesis research	(3)
Fall Semester (FS)	
1. ECE 863 Analysis of Stochastic Systems	(3)
2. Select one of the following:	(3)
ECE 802 Medical Imaging	
ECE 802 Acoustics	
3. ECE 899 Masters thesis research	(3)
Total Credits	(30 or 31)

**M.S. Degree in Electrical Engineering  
with Emphasis on Biomedical Engineering Option II:  
A Sample Program of Study for Biomedical Signal Processing**

Fall Semester (FS)	Credits
1. ECE 863 Analysis of Stochastic Systems	(3)
2. Select one of the following:	(3)
ECE 802 Medical Imaging	
ECE 802 Advanced Signal and Array Processing	
ECE 802 Biomedical Signal Processing	
ECE 802 Biosensor Instrumentation, Processing, and Design	
ECE 466 Digital Signal Processing and Filter Design	
3. Select one of the following:	(3)
PSL 431 Human Physiology	
STT 441 Statistics and Probability	
MTH 425 Complex Analysis	
MTH 451 Numerical Analysis I	
MTH 415 Applied Linear Algebra	
STT 886 Stochastic Processes & App	
Spring Semester (SS)	
1. ECE 864 Detection and Estimation Theory	(3)
2. Select one of the following:	(3 or 4)
NEU 839 Systems Neuroscience	
PSL 432 Human Physiology	
MTH 829 Complex Analysis I	
STT 843 Multivariate analysis	
STT 844 Time Series Analysis	
MTH 840 Chaos and Dynamical Systems	
3. Select one of the following:	(3)
ECE 802 Wavelets and Time-Frequency Analysis	
ECE 802 Image Processing 3	
ECE 802 Information Theory	
ECE 411 Electronic Design and Automation	
Summer Semester (US)	
1. ECE 899 Masters thesis research	(3)

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Fall Semester (FS)

1. ECE 826 Linear Control Systems (3)
2. Select one of the following: (3)
  - ECE 802 Medical Imaging
  - ECE 802 Advanced Signal and Array Processing
  - ECE 802 Biomedical Signal Processing
  - ECE 802 Biosensor Instrumentation, Processing, and Design
  - ECE 466 Digital Signal Processing and Filter Design
3. ECE 899 Masters thesis research

## **COMPUTER ARCHITECTURE AREA**

### **Introduction**

Computer architecture is a bridge area that ties the implementation hardware (devices, circuits, VLSI) with the system (compilers, operating systems) and application software and networks, and as such lies at the heart of Computer Engineering. Researchers in this area work not only in core computer architecture, but also investigate crosscutting architectural issues arising from interactions with the underlying hardware, software, and network. Research contributions may be in the form of new theories, novel design methods backed by simulation, or related to the creation of computational artifacts (modeling, simulation tools, software environments, etc.). Students specializing in Computer Architecture at Michigan State University will acquire the broad background necessary to contribute effectively to the design and implementation of computer architectures that meet application functional requirements as well as cost, power, performance, and reliability goals.

Graduate program coursework at the M.S. and Ph.D. levels is taken in both the Electrical and Computer Engineering (ECE) and Computer Science and Engineering (CSE) Departments. Courses focus on advanced computer architecture, digital electronic circuit and VLSI design, contemporary computer-aided design tools and methodologies, design of systems using embedded processors, design of system-on-a-chip, fault-tolerance, design, test and packaging of application-specific integrated circuits, hardware/software co-design, algorithms, compilers, operating systems, networks, parallel computing, and other specialized courses. Independent study courses may be taken in either Department with a student and faculty member working one-on-one to explore in depth a subject of mutual interest. Faculty with interests in computer architecture include: Professors Mahapatra and Shanblatt. Professor Goodman's work in evolutionary design also has applications to computer architecture.

### **Research Areas**

As minimum features sizes for integrated circuits enter the nanometer regime (sub 100 nm), logic, interconnect, and memory cell behavior change in ways that not only create difficult new challenges, but also exacerbate existing ones. These relate to: power dissipation and density, noise susceptibility, vulnerability to transient and permanent faults, leveraging performance from billions of transistors, and a host of other issues. Further, the increasing complexity of computer systems and their interconnectedness poses significant challenges to managing system complexity and ensuring its dependability. The research challenges relate to: complexity-effective design, pervasive computing, design verification, validation, test, and reuse (IP), RAS (reliability, availability, and scalability), fault tolerance, security, self-sustainability, and other issues. Practical computer architectures must increasingly address these challenges. Research

facilities include numerous laboratories with computational facilities including UNIX-based SUN workstations and a multitude of personal computers, CAD facilities for designing ASICs and FPGAs, hardware prototyping and emulation, hardware simulation, and facilities with state-of-the-art digital test equipment.

**M.S. Degree in Electrical Engineering  
with Emphasis on Computer Architecture:  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. ECE 813 Advanced VLSI Design	(3)
2. CSE 830 Design & Theory of Algorithms	(3)
3. MTH 880 Combinatorics	(3)
Spring Semester (SS)	
1. CSE 812 Advanced Operating Systems	(3)
2. ECE 802 Selected Topics (Embedded Systems)	(3)
3. ECE 820 Advanced Computer Architecture	(3)
Summer Semester (US)	
1. ECE 899 Master's Thesis Research	(3)
Fall Semester (FS)	
1. MTH 852 Num Mthd Ordinary Dif Equation	(3)
2. ECE 816 Cryptography & Network Sec	(3)
3. ECE 899 Master's Thesis Research	(3)
Total credits	(30)

**Partial List of Alternative Courses:**

ECE 410 (4) FS, SS	ECE 921 (3) SS	MTH 850 (3) FS
ECE 411 (4) FS, SS	CSE 410 (3) FS, SS	MTH 851 (3) SS
ECE 466 (3) FS	CSE 420 (3) FS, SS	MTH 810 (3) SS
ECE 474 (3) FS, SS	CSE 422 (3) FS, SS	STT 441 (3) FS, SS
ECE 835 (3) FS	CSE 824 (3) FS	STT 461 (3) SS
ECE 859 (3) SS	CSE 860 (3) SS	

## **COMPUTER NETWORKS AREA**

### **Introduction**

The introduction of wireless networks and its handling of user mobility is perhaps one of the most significant developments of recent years in the rapidly converging areas of pervasive computing and telecommunications. With the introduction of 3G/4G mobile systems, self-organizing sensor and ad hoc networks and the ubiquitous nature of IP connectivity, the technology of mobile networking is likely to be a major growth area in the coming years. In recognition of the importance of this area, the Electrical and Computer Engineering Department of Michigan State University has established a research program in which the students specializing in Computer Networks area are trained on theoretical as well as practical aspects of the technology of computer networks.

Graduate program coursework at the M.S. and Ph.D. levels is taken in both the Electrical and Computer Engineering (ECE) and Computer Science (CSE) Departments. Courses focus on advanced computer networks, mobile network protocols and systems, wireless communication, network security, embedded systems and on advanced algorithms for network protocol design. Independent study courses may be taken in either Department with a student and faculty member working one-on-one to explore in depth a subject of mutual interest. Faculty members with interests in computer networking include Professors Biswas, Li, Radha, and Ren.

### **Research Areas**

Networking research in the ECE Department is structured around three overlapping themes: protocol design, hardware-software development and interdisciplinary network applications. Current research opportunities on wireless protocol research include energy-aware Medium Access Control (MAC) and routing for embedded sensor and Ad Hoc networks, traffic analysis based security mechanisms, multimedia and QoS support, self-organizing MAC, and cross-layer architectures. Research on protocol development deals with self-reorganizing hardware and embedded software design for adaptive network protocols. Challenging research problems exist in this area in the context of energy-constrained embedded applications such as wireless sensor networks. On a more applied front, significant opportunities exist on a number of ongoing projects on developing interdisciplinary applications. These projects include Vehicle-to-Vehicle networking for Intelligent Transportation Systems (ITS), Wireless Sensor Networks for Environmental Monitoring and Networked Systems for Intrusion and Failure Detection of Large Linear Structures.

The research facilities include a number of laboratories with prototype sensor and mobile networks for protocol design, development and performance characterization. In addition, ample computational and hardware facilities are available for embedded system cross-development and network simulation on Linux and Windows based PCs and workstations.



**M.S. Degree in Electrical Engineering  
with Emphasis on Computer Networks:  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. CSE 830 Design & Theory of Algorithms	(3)
2. ECE 863 Analysis of Stochastic Systems	(3)
3. CSE 824 Advanced Computer Network	(3)
Spring Semester (SS)	
1. ECE 820 Advanced Computer Architecture	(3)
2. Select one of the following:	(3)
ECE 802 (selected topics) Multimedia Networking	
ECE-802 (selected topics) Mobile Networks: Protocols and Systems	
3. STT 441 Statistics and Probability	(3)
Summer Semester (US)	
1. ECE 899 Master's Thesis Research	(3)
Fall Semester (FS)	
1. ECE 816 Cryptography and Network Security	(3)
2. STT 886 Stochastic Processes & Application	(3)
3. ECE 899 Master's Thesis Research	(3)
Total Credits	(30)

Partial List of Alternative Courses:

ECE 807 (3) SS	CSE 420 (3) FS, SS	MTH 850 (3) FS	STT 481 (3) FS
ECE 808 (3) FS	CSE 422 (3) FS, SS	MTH 851 (3) SS	STT 844 (3) SS
ECE 829 (3) SS	CSE 848 (3) FS	MTH 828 (3) SS	
ECE 865 (3) FS	CSE 812 (3) SS		
ECE 864 (3) SS	CSE 835 (3) FS		
ECE 851 (3) FS	CSE 830 (3) SS		
ECE 818 (3) SS	CSE 825 (3) FS		
ECE 921 (3) SS			

## **CONTROL AND ROBOTICS AREA**

### **Introduction**

The field of control has a rich heritage of intellectual depth and practical achievements. From the waterclock of Ktesibios in ancient Alexandria to the space probes of today, control systems have played a key role in technological and scientific development. Since the 1960's, there have been many challenges and spectacular achievements in space, aeronautics and industrial automation. Not only control systems have been providing new opportunities in the automotive industry, consumer products, process control, nuclear reactor control, power systems, robotics, manufacturing and defense areas, but also continuously meet new challenges from the frontiers of sciences and technologies such as information technology, biomedical technology and nano technology. Faculty members with research interests in control and robotics include Professors Khalil, Salem, Tan, and Xi. Professor Goodman's work in evolutionary design also has applications to control and robotics.

### **Research**

*Nonlinear Control:* The Control Group at MSU is known internationally for its research in nonlinear control. The group has made fundamental contributions to singular perturbations techniques for multiple-time-scale systems and to the design of output feedback control of nonlinear systems using high-gain observers. Research projects covered problems in robust and adaptive control of nonlinear systems and the nonlinear regulation problem. Applications included mechanical systems and electric drives.

*Robotics and Automation:* The research in Robotics and Automation group at MSU is focused on the systems and large scale networks, such as control systems, communication systems, robotic and manufacturing systems, and applying robotics and automation technologies to solve the problems in different application domains such as automotive, biomedicine, and nano technology. The research activities include system modeling and analysis, sensor integration and data fusion, controller design, human and computer interaction, and real-time computing architecture and software development. The ultimate goal is to develop theoretical foundations as well as implementation schemes for systems and large scale networks to increase their efficiency, reliability and safety, and to achieve a robust and intelligent system performance. The problems studied here involve both theoretical development in new methodologies for planning and control, as well as implementation problems in hardware architectures, sensory measurement, and computer software development.

*Modeling and Control of Smart Materials and Microsystems:* The Smart Systems Group applies the theory of controls and dynamical systems to the emerging areas of smart materials and structures, micro-electromechanical systems (MEMS), and networked systems. The research into smart materials and MEMS includes multi-scale modeling and computation, controller design, and real-time control implementation. Current projects include modeling and control of magnetostrictive actuators, electroactive polymers, and microball-bearing supported micromotors. The research into networked control systems (e.g., groups of robots, swarms of unmanned aerial vehicles, and MEMS actuator and sensor networks) is focused on the understanding of tradeoffs among competing goals in such systems, and the development of enabling architectures and mechanisms for decentralized/distributed control.

**M.S. Degree in Electrical Engineering  
with Emphasis on Control/Robotics:  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. ECE 851 Linear Systems and Control (ECE 826)	(3)
2. ECE 863 Analysis of Stochastic Systems	(3)
3. MTH 415 Applied Linear Algebra	(3)
Spring Semester (SS)	
1. ECE 818 Robotics	(3)
2. ECE 853 Optimal Control	(3)
3. ECE 859 Nonlinear Systems and Control	(3)
Summer Semester (US)	
1. Masters Thesis Research	(4)
Fall Semester (FS)	
1. MTH 421 Analysis II	(3)
2. <i>Select one of the following:</i>	(3)
ECE 854 Robust Control	
ECE 856 Adaptive Control (ECE 960A)	
3. Masters Thesis Research	(2)
Total credits	(30)

Partial List of Alternative Courses

ECE 823 (3) FS, even	MTH 451 (3) FS	STT 441 (3) FS,SS,US
ECE 824 (3) FS, odd	MTH 424 (3) SS	
ECE 825 (3) SS, even		
ECE 831 (3) FS, even		
ECE 864 (3) SS		
ECE 885 (3) FS		

## **ELECTROMAGNETICS AREA**

### **Introduction**

Maxwell's equations succinctly embody the laws of electrodynamics and constitute the fundamental physics beneath electrical, electronic, communication, computer, optical, biological, and geophysical technologies. While simple and elegant in form these equations pose numerous challenges when applied to the analysis of practical problems. Over the past century, electromagnetics has played a key role in the development of various technologies; and it continues to play a significant role in all the aforementioned areas. Graduate students plan their M.S. and Ph. D program by choosing from a range of comprehensive course offerings. Fundamental concepts are treated in the Master's level course while more specialized set of courses supplement the research program. Laboratories are available to support the research program. The facilities available, and more importantly, research being pursued are intended to train students into being independent thinkers, and perform cutting edge research in either a University, or Government, or Industrial setting. Faculty with research interests in Electromagnetics include: Professors Asmussen, Balasubramaniam, Kempel, Ramuhalli, Rothwell, L. Udpa, and S. Udpa.

### **Research areas**

The EM group at MSU enjoys an international recognition in the study of applied electromagnetics. Research at MSU comes in two flavors; (i) experimental research, and (ii) development and the application of novel computational electromagnetic tool-boxes. More often than not, faculty in these two sub-areas work in concert with each other to solve specific problems. Research at MSU covers a large frequency range, from the microwave regime to statics. In what follows, we shall briefly list some of the projects being pursued:

In experimental research, students and faculty are developing smart antennas that responds to changing signals received, developing methods for materials characterization in both frequency and time domains, design of novel radar systems and radar sensing applications, design of RF antennas for breast-cancer therapy, developing non-destructive evaluation techniques for characterizing structural integrity, magnetic flux leakage and eddy-current measurement techniques. In addition, MSU is internationally renown for its research in microwave plasma applicators, both design and use in plasma enhanced chemical vapor deposition processes.

In the computational arena, the focus has been to develop rigorous physics based "fast" models that have a lower computational overhead than classical methods while preserving accuracy. To this end, we are working on fast time and

frequency domain integral equation solvers, higher order finite element method, meshless methods, hybrid circuit simulators, etc. Application of these tools ranges from nanophotonics to RCS computations, design of conformal antennas, design of materials, and characterization for high-speed circuit analysis.

**M.S. Degree in Electrical Engineering  
With Emphasis in Electromagnetics  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. ECE 835 Electromagnetics Fields and Waves I	(3)
2. ECE 405 Electromagnetic Wave and Applications	(3)
3. MTH 451 Numerical Analysis I	(3)
Spring Semester (SS)	
1. ECE 407 EMI/EMC	(3)
2. <i>Select which ever is offered</i>	(3)
ECE 802 Canonical Problems in Electromagnetics	
ECE 836 Introduction to Computational Electromagnetics	
3. MTH 829 Complex Analysis	(3)
Summer (US)	
1. ECE 899 Research Credits	(4)
Fall (FS)	
1. ECE 929 Advanced Topics in Electromagnetics	(3)
2. ECE 874 Physical Electronics	(3)
3. ECE 899 Research Credits	(2)
Total credits	(30)

Partial list of alternative courses

ECE 864 (3) SS	MTH 842 (3) SS	PHY 472 (3) SS
MTH 424 (3) FS, SS, US	MTH 850 (3) FS	PHY 841 (3) FS
MTH 841 (3) FS	MTH 851 (3) SS	PHY 842 (3) SS
PHY 425B (3) US	PHY 851 (3) FS	PHY 852 (3) SS

## **ELECTRONIC MATERIALS AND DEVICES AREA**

### **Introduction**

Much of the infrastructure that has facilitated the remarkable advances in electronic and computer technology has been based on advances in electronic materials and devices. Research at Michigan State University in electronic materials and devices includes simulation, design, fabrication, characterization and applications. Fabrication involves materials synthesis by a variety of methods. It also includes microlithography and a variety of etching methods in a cleanroom environment designed to facilitate exploration of new materials and device structures, including microelectromechanical systems (MEMS), integrated microsystems and nanoscale devices. A variety of characterization equipment is available in modern, well equipped laboratories. Graduate students plan their M.S. or Ph.D. programs by selecting from comprehensive graduate course listings. Fundamental electrosience concepts are treated in Master's level courses while advanced research development courses support the various research specializations. Faculty members with research interests in electronic materials and devices include Professors Aslam, Asmussen, Ayres, Brown, Grotjohn, Hogan, and Reinhard.

### Research Areas

Research activities include participation in two world-class research centers; the Fraunhofer Center for Coatings and Laser Applications located at the MSU campus and the National Science Foundation Engineering Research Center for Wireless Integrated Micro-Systems (WIMS) awarded to 3 Michigan universities (The University of Michigan, Michigan State University, and Michigan Technological University).

The MSU research in the WIMS Center focuses on micro- and nano-fabrication technologies based on polycrystalline diamond (poly-C) and carbon nanotubes (CNT). Specific examples of current research projects include CNT adsorbent layers for on-chip gas chromatograph, poly-C position sensors for cochlear implant, poly-C RFMEMS resonators and poly-C MEMS packaging.

The research in the Fraunhofer Center includes the invention, design, and application of synthesis machines and technologies for novel materials and device structures. A particular focus is on the adaptation of microwave and plasma technology for a wide variety of materials processing applications.

Additional research includes the investigation of electronic/structural properties and biocompatibility of nanostructures, the growth mechanisms of carbon nanostructures, amorphous tetrahedral carbon, diamond, silicon nanowires,



scanning probe microscopy and nanomanipulation. Synthesis, fabrication and characterization studies include pulsed laser deposition of novel electronic materials, thermoelectric materials, quantum well structures, charge transport characterization of electronic materials, and on-wafer optical structures. The design, growth, and investigation of compound semiconductors for device applications using in-situ monitoring, is coupled with statistical analysis and advanced modeling techniques.

**M.S. Degree in Electrical Engineering  
with Emphasis on Electronic Materials and Devices  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. ECE 874 Physical Electronics	(3)
2. ECE 835 Advanced Electromagnetic Fields and Waves I	(3)
3. ECE 870 Introduction to Micro-Electric-Mechanical Systems	(3)
Spring Semester (SS)	
1. ECE 875 Electronic Devices	(3)
2. <i>Select one of the following</i>	(3)
ECE 850 Electrodynamics of Plasmas	
ECE 836 Advanced Electromagnetic Fields and Waves II	
ECE 813 Advanced VLSI Design	
3. ECE 871 MEMS Fabrication	(3)
Summer Semester (US)	
1. ECE 899 Master's Thesis Research	(4)
Fall Semester (FS)	
1. <i>Select one of the following</i>	(3)
MTH 451 Numerical Analysis I	
STT 441 Probability and Statistics 1	
2. <i>Select one of the following</i>	(3)
PHY 471 Quantum Physics I	
PHY 491 Atomic, Molecular, and Condensed Matter Physics	
3. ECE 899 Master's Thesis Research	(2)
Total credits	(30)

Partial List of Alternative Courses

ECE 474 (3) FS, SS	Phys 851 (3) FS	MTH 424 (3) SS, US
ECE 476 (4) FS	Phys 852 (3) SS	MTH 451 (3) FS
ECE 477 (3) FS	NSC 802 (2) FS	MTH 851 (3) FS
ECE 841 (3) SS		MTH 852 (3) SS

## **POWER AREA**

### **Introduction**

The work in the power area involves courses and research on power systems, electrical machines, and electric drives.

Deregulation will result in (a) less predictability of both load and generation and (b) larger power transfers across utility boundaries. These factors have introduced the threat of new and different stability problems. New methods of stabilizing and operating the power system are required to solve these stability problems. Intelligent control to determine the location, and subsystems initiating possible blackouts, the equipment outages that produce them, and a diagnostic for deciding the cause and cure will be required to maintain high levels of reliability utility customers have come to expect. Intelligent control is also needed to develop scheduling dispatch, and stabilization methods appropriate to a deregulated power industry.

Rapid advances in semiconductor and computing technology and the demand for higher efficiency and better control has led to the integration of power semiconductors into loads (for example: motor drives, process and illumination controllers). Work on electrical drive systems involves the design of new electrical machines tuned to the application, the development of new control methodologies to improve the response of a motor while using fewer sensors, and innovation in power electronics to reduce losses and improve response. Applications range from the automotive and aerospace industries to manufacturing and appliances. This power electronics technology is also being used to help control and stabilize the power system needed if the nations electric utility industry is to maintain our current level of reliability after deregulation is complete.

The power system laboratory contains computer and power system software that are the best available and, in some cases, not available in other university power system research laboratories. The power research and teaching laboratory is one of the finest in the country. It allows the students and researchers to experiment with computer controlled electrical machines, drives, and power electronics systems. Faculty members with research interests in power include Professors Peng, Schlueter, and Strangas.

### **Research Areas at MSU**

The faculty members are actively pursuing research that addresses the problems associated with (1) power system analysis for scheduling, control, and stabilizing power systems; (2) developing improved motors, power electronic drives, and

converters; and (3) improving distribution and customer system operation and protection. Current research opportunities in each of these three areas are listed as follows

Solution of electromagnetic fields in machines and transformers;

Power electronics in motors and power systems;

Motor drives and controllers

Special purpose machines

Stability of Power Systems

Security and Stability Assessment and Diagnosis Intelligent

Control of Power Systems

Operation of Power Systems

**M.S. Degree in Electrical and Computer Engineering  
With Emphasis in Power Systems or Machines and Drives  
A Sample Program of Study**

Fall Semester (FS)	Credits
1 <i>Select one of the following</i>	(3)
ECE 825 Alternating Current Electrical Machines and Drives (odd years)	
ECE 824 Power System Operation and Control I(odd years)	
ECE 823 Power System Stability and Control (even years)	
2 <i>Select one of the following</i>	(3)
ECE 851 Linear Control Systems (ECE 826)	
ECE 835 Electromagnetic Fields and Waves I	
ECE 863 Analysis of Stochastic Systems	
3 <i>Select one of the following</i>	(3)
MTH 421 Analysis I	
MTH 424 Applied Advanced Calculus	
MTH 451 Numerical Analysis I	
STT 441 Statistics and Probability I	
Spring Semester (SS)	
1 <i>Select one of the following.</i>	
ECE 925 Advanced Machines (even years)	(3)
Intelligent Control of Power Systems( odd years)	
2 <i>Select one of the following</i>	(3)
MTH 421 Analysis II	
MTH 452 Numerical Analysis II	
STT 442 Statistics and Probability II	
3 <i>Select one of the following</i>	(3)
ECE 859 Nonlinear Systems and Control	
ECE 864 Detection and Estimation	
Summer Semester (US)	
M.S. Thesis Research	(4)

Fall Semester (FS)	
1 <i>Select two of the following</i>	(6)
ECE 825 Alternating Current Electrical Machines and Drives (odd years)	
ECE 824 Power System Operation and Control (odd years)	
ECE 823 Power System Stability and Control (even years)	
2 M.S. Thesis/Research	(2)
Total credits	(30)

#### Partial List of Alternative Courses

ECE 821 (3) FS, odd  
 ECE 863 (3) FS  
 ECE 835 (3) FS  
 ECE 420 (3) SS  
 ECE 485 (4) SS

## **SIGNAL PROCESSING AND COMMUNICATIONS AREA**

### **Introduction**

The signal processing and communications area includes topic related to the electrical, magnetic, and computer processing of information-bearing signals. SP&C courses and research involve techniques for modeling systems that generate and process information, and for modeling channels over which information is transmitted. Emphasis is placed on the mathematical understanding of systems, signals, and processing techniques and their practical applications.

The SP&C area has undergone explosive growth in recent decades. New computing technologies have revolutionized both long and short distance communication systems as well as the systems for performing local computations such as filtering, coding, and pattern recognition. Modern high-capacity communication channels reliably carry text, data, voice, video, and other information messages over satellite links, optical fiber networks, wireless channels, and broadband network services into the office and private homes. SP&C applications are found in every spectral range, from low frequency biological or geophysical signals, to audio and video bands, and on up to the microwave and optical bands.

Interest in information processing technology represented by the SP&C area continues to grow dramatically, and engineers with graduate degrees in this area are in high demand by analog and digital communication industries, high technology research and development companies, government laboratories, universities, and many other companies with information and data handling needs. Faculty members with research interests in the Communications and Signal Processing Area are Professors Aviyente, Chakrabarty, Deller, Jain, Li, Mukkamala, Oweiss, Radha, Ramuhalli L. Udpa and S. Udpa.

### **Research Areas**

Research in SP&C at MSU is best characterized by the term "statistical signal processing." This term is becoming universally used to designate a broad subdiscipline concerned with signal processing in the presence of changing uncertainties. The focus of statistical signal processing is upon mathematical techniques that provide adaptively optimal solutions in the presence of the non-ideal conditions occurring in real problems. Applications of statistical signal processing results are very broad. Current MSU research involves speech recognition, biomedical signal processing, wireless communications, array processing, speech and image coding, multimedia over wireless networks, neural networks, and non-stationary signal processing. Opportunities exist for SP&C

research students to interact with many faculty in related areas such as non-destructive evaluation, VLSI and parallel architectures, and pattern recognition.



**M.S. Degree in Electrical Engineering  
with Emphasis on Signal Processing and Communications:  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. ECE 466 Digital Signal Processing and Filter Design	(3)
2. ECE 863 Analysis of Stochastic Systems	(3)
3. MTH 428H Honor Analysis I	(3)
Spring Semester (SS)	
1. ECE 864 Detection and Estimation Theory	(3)
2. MTH 828 Real Analysis I	(3)
3. <i>Select one of the following</i>	(3)
ECE 802 Selected Topics	
ECE 966 Advanced Topics in CSP	
Summer Semester (US)	
1. ECE 899 Masters Thesis Research	(4)
Fall Semester (FS)	
1. ECE 865 Digital Communication Systems	(3)
2. ECE 851 Linear Control Systems	(3)
2. ECE 899 Masters Thesis Research	(2)
Total credits	(30)

Partial List of Alternative Courses:

ECE 457 (3) SS	CSE 471 (3) FS	MTH 425 (3) FS, SS	STT 441 (3) FS, SS, US
ECE 458 (1) SS	CSE 838 (3) SS	MTH 443 (3) FS	STT 844 (3) SS
ECE 809 (3) FS	CSE 835 (3) FS	MTH 461 (3) FS	STT 861 (3) FS
ECE 966 (3) SS	CSE 802 (4) SS	MTH 415 (3) FS, SS	STT 862 (3) SS
ECE 853 (3) SS	CSE 803 (3) FS	MTH 810 (3) SS	
ECE 841 (3) SS	CSE 808 (3) FS		
	CSE 822 (3) SS		

## **VLSI AND MICROELECTRONICS CIRCUIT AREA**

### **Introduction**

As we enter a new century we are witnessing a period of radical development in very large scale integrated systems (VLSI), the proliferation of embedded computers and entire systems being built on a single chip. This has come about because of the remarkable advances in integrated circuit processing technology that have seen dramatic increases in chip complexities, while the manufacturing cost of a chip has remained fairly constant. It has been predicted that this trend will continue unabated with more than a billion gates per chip. But what can we do with this technology? How can we best use it? Students specializing in VLSI and microelectronics circuit at Michigan State University are developing the theoretical foundation and practical hands-on experience necessary to answer these questions.

Graduate program coursework at the M.S. and Ph.D. levels is taken in both the Electrical and Computer Engineering (ECE) and Computer Science (CSE) Departments. Courses focus on advanced digital electronic circuit design, mixed-signal and analog circuits, contemporary computer-aided design tools and methodologies, design of systems using embedded processors, design of system-on-a-chip, fault-tolerant and packaging design issues, the design, test and packaging of application-specific integrated circuits (ASICs), hardware/software co-design and artificial intelligence. Independent study courses may be taken in either Department with a student and faculty member working one-on-one to explore in depth a subject of mutual interest. Faculty members with research interests in VLSI and microelectronic circuits include Professors Chakrabarty, Mason, Mahapatra, Salem, Shanblatt and Wierzbica.

### **Research Areas**

Research opportunities in VLSI and Microelectronics Circuit at MSU are varied and deal with challenging problems centered on the microelectronics, architecture, design and verification of VLSI systems. Faculty and graduate students work together and in multidisciplinary teams on these research problems with funding coming from a variety of governmental agencies and private industry. Challenging research emphasis is available on topics such as analog mixed-signal IC design and testing, logic design and VLSI implementation, low-power design, design automation, circuit testing and design verification, sensor networks, system-on-a-chip, hardware-software co-design, embedded systems, rapid prototyping, multi-chip module and MEMS hardware, nano-scale design and analysis, and system modeling.

The research facilities include numerous laboratories with computational facilities including UNIX-based SUN workstations and a multitude of personal computers, CAD facilities for designing ASICs and FPGAs, hardware prototyping and emulation, and facilities with state-of-the-art analog and digital test equipment.

**M.S. Degree in Electrical Engineering  
with Emphasis on VLSI and Microelectronics Circuit:  
A Sample Program of Study**

Fall Semester (FS)	Credits
1. MTH 481 Discrete Mathematics I	(3)
2. ECE 826 Linear Control Systems	(3)
3. ECE 831 Analog Circuit Theory	(3)

Spring Semester (SS)	
1. ECE 813 Advanced VLSI Design	(3)
2. ECE 802 Selected Topics: (Low Power VLSI)	(3)
3. STT 441 Statistics and Probability I	(3)

Summer Semester (US)	
1. ECE 899 Master's Thesis Research	(4)

Fall Semester (FS)	
1. ECE 814 Embedded Transceivers	(3)
2. ECE 820 Advanced Computer Architecture	(3)
3. ECE 899 Master's Thesis Research	(2)
Total credits	(30)

Partial List of Alternative Courses:

ECE 410 (4) FS, SS	CSE 410 (3) FS, SS	MTH 850 (3) FS
ECE 411 (4) FS, SS	CSE 420 (3) FS, SS	MTH 851 (3) SS
ECE 466 (3) FS	CSE 422 (3) FS, SS	
ECE 474 (3) FS, SS		
ECE 835 (3) FS		
ECE 859 (3) SS		
ECE 921 (3) SS		

## **Appendix 4 – Designing Your M.S. Program in Electrical Engineering**

This appendix is intended to provide assistance in designing your M.S. Program in Electrical Engineering. The program is to be filed before 6 credits are finished.

1. Use the work sheet supplied in this Appendix in preparation to meeting with your advisor.
2. After you and your advisor agree on a program of courses, use the web based 'gts2' system in the Engineering College to submit the program. The web site is <https://www.egr.msu.edu/apps/gts2/>
3. The graduate secretary will review the program with regard to meeting criteria such as satisfying the minimum number of credits, minimum number of core classes, and so forth. The graduate secretary will print a paper copy of the plan.
4. The secretary will contact you when the plan is ready for your signature. After you sign it, it is to be signed by your advisor, the Associate Chairperson for Research and Graduate Studies, and the Associate Dean of Engineering to indicate that they all approve it.

Included with this appendix is an example of a Master's Degree Program Plan. The plan constitutes a written agreement. It can be changed, but to do so requires that all the original signatories sign the revised plan to show their approval. Revisions to the Master's Degree Program Plan are also made at the gts2 web site. A revised plan will show which courses are being dropped and which are being added in the revision process.

With reference to the student's approved program of study, none of the following types of changes will be approved:

1. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass-No Grade, or Credit-No Credit).
2. Adding or deleting a course for which grading was postponed by the use of the DF-Deferred marker.
3. Adding or deleting a course which the student dropped after the middle of a semester and for which a 'W' or 'N' or '0.0' was designated.
4. Adding or deleting a course during the final semester of enrollment in the master's degree program.

## **Worksheet: Planning Your M.S. Program in ECE at Michigan State University**

1. The six credits to meet the core requirement are (circle 2 courses from the listed below):

ECE 813	Advanced VLSI Design
ECE 820	Advanced Computer Architecture
ECE 821	Advanced Power Electronics and Applications
ECE 826	Linear Control Systems
ECE 835	Advanced Electromagnetic Fields and Waves I
ECE 863	Analysis of Stochastic Systems
ECE 874	Physical Electronics

2. The six credits in areas such as Mathematics, Statistics, and Physics are:

MTH 415, 421, 424, 425, 428H, 443, 451, 452, 461, 472,  
MTH 810, 828, 829, 841, 842, 848, 849, 850, 851, 852, 881  
STT 441, 442, 844, 861, 862  
PHY 425B, 471, 472, 810, 841, 842, 851, 852  
or other: \_\_\_\_\_

3. The number of ECE 899 thesis credits are: \_\_\_\_\_

4. Additional courses taken to meet breadth and depth interests are listed below (note these must include at least six credits from ECE courses at the 800 level or 900 level, not including ECE 801):

---

---

5. Check to make sure your program meets the University, College, and Department requirements as listed in the ECE Graduate Student Handbook and the MSU publication Academic Programs. Some important check list items are:

- My advisor approves of these courses.
- I will have the necessary prerequisites .
- The courses are to be offered in the terms in which I plan to take them.
- The total number of credits is at least 30.
- All courses are at the 400 level or higher.
- If Plan A (with thesis), the number of ECE 899 credits is between 4 and 8.
- If Plan A (with thesis), the number of 800 level credits is at least 20.
- If Plan B (no thesis), the number of 800 level credits is at least 18.

# Sample Master's Degree Program Plan.

MICHIGAN STATE UNIVERSITY

COLLEGE OF ENGINEERING

## Master's Degree Program Plan

Name: Student, Joe

Date: 09/01/05

PID: A0000000

First Semester in Master's Program: FS05

Major: **Electrical Engineering**

Status: **Regular**

Plan: **Plan A Thesis Work (MS:Thesis)**

New Plan:

Added	Course	Title	Semester	Credits	Grade	Remarks
*	ECE 466	Digital Signal Processing and Filter Design	FS05	3		
*	ECE 863	Analysis of Stochastic Systems	FS05	3		
*	MTH 428H	Honor Analysis I	FS05	3		
*	ECE 864	Detection and Estimation Theory	SS06	3		
*	MTH 828	Real Analysis	SS06	3		
*	ECE 867	Information Theory and Coding	SS06	3		
*	ECE 899	Masters Thesis Research	US06	3		
*	ECE 865	Digital Communication Systems	FS06	3		
*	ECE 899	Master's Thesis Research	FS06	3		
*	ECE 851	Linear Control Systems	FS06	3		

Credits 500 Level and Above	Thesis Credits	Total Credits
24	6	30

Removed Courses:

None

Joe Student 9/2/05  
Joe Student Date

Jane Faculty 9-2-05  
Jane Faculty Date

Jack Coordinator 9/3/05  
Dept Chair / Grad Coordinator Date

Till Dean 9-8-05  
Associate Dean Date

After you submit your Master's Degree Program Plan online, the graduate secretary will review the program and print out a hard copy. The secretary will contact you when the plan is ready for your signature.

## **Appendix 5 – Designing Your Ph.D. Program in Electrical Engineering**

This document is intended to provide assistance in designing your Ph.D. Program in Electrical Engineering. The program is to be filed within the first two semesters of your program.

1. You may wish to use the work sheet supplied in this document in planning your course work.
2. After you and your guidance committee agree on a program of courses for your doctoral studies, use the web based 'gts2' system in the Engineering College to submit the program. The web site is <https://www.egr.msu.edu/apps/gts2/>
3. The graduate secretary will review the program with regard to meeting criteria, such as satisfying the minimum number of credits, and will then print a paper copy of the plan.
4. The secretary will contact you when the plan is ready for your signature. After you sign it, it is to be signed by the guidance committee members, the Associate Chairperson for Research and Graduate Studies, and the Associate Dean of Engineering to indicate that they all approve it.

Also included with this document is an example of a Ph.D. Program Plan that is to be filed by the student. It consists of two pages. The first page, titled 'Doctoral Degree Program Plan' lists the MSU courses that will be, or have been, taken as part of the Doctoral Program in Electrical Engineering. This page is generated by the gts2 system and must not include courses used for another graduate degree. The second page titled 'Supplement to the Report of the Guidance Committee' lists other post-bachelor graduate-level classes that are counted by the guidance committee as part of the 36 credit minimum course requirement. The Supplement to the Report of the Guidance Committee is not generated by the gts2 system. It can be obtained from the graduate secretary and filled in by hand as shown in the example. Courses on the second page would include those taken at as part of a graduate degree program at another university and also those taken at Michigan State University as part of a different graduate degree plan. Note that students going directly into the doctoral program after the bachelor's degree will not use the second page.

Note that all courses counted toward the 36 credit minimum must be graduate level – not dual-level undergraduate/graduate courses. Also note that in addition to the courses on the Doctoral Degree Program all doctoral candidates must complete at least 24 credits of doctoral dissertation research, ECE 999. Note that ECE 999 credits are not specifically listed as part of the Doctoral Program Plan.

The sample program shown here has 21 credits on the Doctoral Degree Program Plan and 18 credits on the Supplement to the Report of the Guidance Committee, totaling 39 credits which exceed the 36 credit minimum. Note that in this example case, the graduate courses on the Supplement to the Report of the Guidance Committee are from a different university.

The doctoral plan constitutes a written agreement. It can be changed, but to do so requires that all the original signatories sign the revised plan to show their approval. Revisions to the Doctoral Degree Program Plan are made at the gts2 web site. A revised plan will show which courses are being dropped and which are being added in the revision process.

With reference to the student's approved program of study, none of the following types of changes will be approved:

1. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass-No Grade, or Credit-No Credit).
2. Adding or deleting a course for which grading was postponed by the use of the DF-Deferred marker.
3. Adding or deleting a course which the student dropped after the middle of a semester and for which a 'W' or 'N' or '0.0' was designated.
4. Adding or deleting a course during the final semester of enrollment in the master's degree program.



## **Worksheet: Planning Your Ph.D. Program in ECE at Michigan State University**

1. Courses to be taken or courses that have been taken at MSU for your doctoral program. These courses must not have been used on other graduate degree or undergraduate degree programs. (Note these courses will be listed on the gts2 system generated form titled "Doctoral Degree Program Plan").

2. Courses used in previous graduate programs at MSU, or post-bachelor's courses taken elsewhere, that the Guidance Committee agrees to use toward the 36 credit post-bachelors degree minimum. (Note: these courses will be listed on the form "Supplement to Report of the Guidance Committee").

All of these must be graduate level. Dual level (senior/grad) courses are not to be included.

3. Check to make sure your program meets the University, College, and Department as listed in the ECE Graduate Student Handbook and the MSU publication Academic Programs. Some important check list items are:

- My advisor and the other members of my guidance committee approve of these courses.
- I will have the necessary prerequisites .
- The courses are to be offered in the terms in which I plan to take them.
- The total number of credits is at least 36.
- All courses are at the 800/900 level.
- At least 3 of the credits are in mathematics, statistics, or physics.
- All courses are on the numerical grading system, with the exception of up to 3 credits of M.S. thesis. Independent study is not used as part of the 36 credit minimum.

# Sample Doctoral Program

MICHIGAN STATE UNIVERSITY

COLLEGE OF ENGINEERING

## Doctoral Degree Program Plan

Name: **Student, Jane**

Date: 03/01/05

PID: **A00000000**

First Semester in Doctoral Program: **FS04**

Major: **Electrical Engineering**

Status: **Regular**

New Plan:

Added	Course	Title	Semester	Credits	Grade	Remarks
	PHY 810	Methods of Theoretical Physics	FS06	3		
	ECE 929B	Antenna Theory	SS06	3		
	ECE 871	Micro-electro-mechanical Systems	SS06	3		
	ECE 931C	Properties of Semiconductors	FS05	3		
	ECE 836	Electromagnetic Fields and Waves II	SS05	3		
	ECE 875	Electronic Devices	FS04	3	3.5	
	ECE 859	Optimal Multivariable Control	FS04	3	4.0	

Credits 500 Level and Above	Thesis Credits	Total Credits
21		21 -

Removed Courses:

None

*Jane Student*  
Jane Student

*3-1-05*  
Date

*Ann Advisor*  
Ann Advisor

*3/2/05*  
Date

*George Guidance 1*  
George Guidance1

*3/3/05*  
Date

*George Guidance 2*  
George Guidance2

*3/4/05*  
Date

*George Guidance 3*  
George Guidance3

*3/04/05*  
Date

*Jack Coordinator*  
Dept Chair / Grad Coordinator

*3/5/05*  
Date

*Jill Dean*  
Associate Dean

*3-8-05*  
Date

Courses listed on this plan must not include courses from other graduate degree plans. Do not include ECE 999 credits on this form.

## Sample Supplementary Report.

## Department of Electrical and Computer Engineering

## SUPPLEMENT to the REPORT OF THE GUIDANCE COMMITTEE Form

Use this form to list post-bachelor's courses accepted by the Doctoral Guidance Committee towards the Departmental minimum Ph.D. course credit requirement (36 credits). The form is to be attached to the MSU College of Engineering Doctoral Degree Program Plan.

[illegible]

## **Appendix 6 – Dual Major Doctoral Degrees**

The Department of Electrical and Computer Engineering supports interdisciplinary Ph.D. programs centered on the student's pursuit of an interdisciplinary dissertation topic. The primary goals of such a program are to foster cutting-edge interdisciplinary research and to provide an educational experience for these dual doctorate students that makes them highly qualified for their future careers.

Under MSU guidelines, research-based graduate degrees can be designed across disciplines/graduate programs, with the concurrence of the graduate programs involved (see Dual Major Doctoral Degrees in the MSU Publication "Academic Programs"). The interdisciplinary graduate degrees outlined here involve the Department of Electrical and Computer Engineering together with another department (e.g., Physics), with one department being the student's primary affiliation (the department to which he or she was admitted to MSU Graduate School) and the other a secondary affiliation. Admission requirements to graduate school are based on the primary department. A request for a dual major degree must be submitted within one semester following the admission into the Ph.D. program and within the first two years of the student's graduate enrollment at MSU. This document represents a template for the overall requirements for the dual degree. The specific requirements depend on the agreements reached between the Electrical and Computer Engineering Department and the other department and stated in a subsidiary document. The remaining requirements depend on whether the Department of Electrical and Computer Engineering will be the primary or secondary affiliation for the student.

### **Primary Affiliation Case**

The requirements for a student pursuing a Ph.D. where Electrical and Computer Engineering is the major department are as follows.

1. The course work must be satisfactory to the members of the advisory committee of both departments. The ECE department requires that the student take 36 credits post-bachelors degree at the 800 level and must take one course outside the department and college at the 800 level.
2. He/she must pass the Electrical and Computer Engineering Ph.D. qualifying exam and could be given one exam reflecting the dual nature of the degree to replace one out of the three that reflect an area of Electrical and Computer Engineering.
3. The advisor must be a faculty member of either the primary or secondary department and the co-advisor must be from the other department.

4. The guidance committee must be comprised of at least five faculty members with at least three faculty members from the Electrical and Computer Engineering Department and at least two faculty members from the secondary department.
5. Comprehensive examinations must be passed to the satisfaction of both departments.
6. The academic program was developed in consultation with the student. The guidance committee should be satisfied that the dissertation represents a contribution meeting the usual standards in both areas.
7. The Office of the Graduate School review will include the appropriateness of the guidance committee membership, the academic program, and the courses or credits applied to the two programs.

### **Secondary Affiliation Case**

The requirements for a student pursuing a Ph.D. where Electrical and Computer Engineering is the secondary department are as follows.

1. He/ She must either show a proficiency in three of the four undergraduate courses ECE 302, 305, 313 and 366.
2. The advisor can be a faculty member of either the primary or secondary department and the co-advisor must be from the other department.
3. The guidance committee must be comprised of at least five faculty members with at least three faculty members from primary department and at least two faculty members from the Electrical and Computer Engineering department.
4. The course work must be satisfactory to both departments.
5. Four graduate level courses must be taken in Electrical and Computer Engineering and one must be a core course.
6. The Graduate Studies Committee in consultation with the Ph.D. Guidance Committee may require an Electrical and Computer Engineering Ph.D. qualifying exam and its format.
7. Comprehensive examinations must be passed to the satisfaction of both departments.
8. The academic program must be developed in consultation with the student. The guidance committee must be satisfied that the dissertation represents a contribution meeting the usual standards in both areas.
9. The Office of the Graduate School review will include appropriateness of the guidance committee membership, the academic program, and the courses or credits applied to the two programs.

## **Appendix 7 – Forms and checklists**

## LETTER OF RECOMMENDATION

Applicant

Name: \_\_\_\_\_  
Last First Middle

### DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING MICHIGAN STATE UNIVERSITY

To Applicant:

The Family Education and Privacy Act of 1974 gives students the right to inspect letters of recommendation written in support of applications for admission or fellowship. This law also permits students to waive that right if they so choose, although such a waiver cannot be a condition of admission or award. If you wish to waive your right to examine this letter of recommendation please sign the waiver below.

The following signed statement indicates the wish of the applicant regarding this recommendation.

I do waive \_\_\_\_\_ I do not waive \_\_\_\_\_ my right of access to the information in this recommendation

Signed \_\_\_\_\_ Date \_\_\_\_\_

To Recommender:

A. Please rate this applicant in overall promise for graduate work.

BELOW AVERAGE	AVERAGE	SOMEWHAT ABOVE AVERAGE	GOOD	EXCELLENT	OUTSTANDING	TRULY EXCEPTIONAL	INADEQUATE OPPORTUNITY TO OBSERVE
LOWEST 40	MIDDLE 20	NEXT 15	NEXT HIGHEST 15	HIGHEST 10			

B. The applicant's actual (if available) or approximate rank in his/her class is \_\_\_\_\_ out of \_\_\_\_\_ students.

C. How long have you known the applicant and in what capacity?

D. Please write additional comments about the applicant's capacity for serious scholarship and research.  
(Please use the back of this form or an attached page.)

Signature \_\_\_\_\_ .....Date \_\_\_\_\_

Name (print) \_\_\_\_\_ Position \_\_\_\_\_

Institution \_\_\_\_\_ Email \_\_\_\_\_

Address \_\_\_\_\_

#### Return to:

Dept. of Electrical & Computer Engineering  
Attn: ECE Graduate Application Processing  
Michigan State University  
2120 Engineering Building  
East Lansing, MI 48824-1226

### **New Student Check list.**

- ☐ **University Picture ID** – 150 Administration Building (Registrar's Office) 353-3300.
- ☐ **University email account** – see <http://help.msu.edu/activate/> for instructions on how to set up your university email account. This must be done before your Engineering College computer accounts can be set up.
- ☐ **Department Picture** – Appointment date to be scheduled with the ECE Graduate Secretary.
- ☐ **Engineering College computer account and email** – Division of Engineering Computer Services, 1325 Engineering Building
- ☐ **Apply for social security card** – Applications are available at the office for International Students & Scholars, 103 International Center, 353-1720.
- ☐ **Complete I-9 Form (TA/RA graduate assistants ONLY)** – Forms are available at 103 International Center. Return the form to Sheryl Hulet, 2120 Engineering Building.
- ☐ **Graduate Employees Union deduction/authorization form/membership card** – All teaching assistants, except for those teaching assistants specifically excluded by the MSU/GEU agreement, must fill out this card and check-off of the option of either union membership dues or representation fees
- ☐ **Vehicle Registration** – The Police & Public Safety Office is located at 870 Red Cedar Road (355-8440). You will need a copy of your vehicle registration and car insurance. If you are a TA/RA, you will need a copy of your Graduate Appointment Form, which you can get from Sheryl Hulet at 2120 Engineering Building.
- ☐ **Housing** – 355-7457 (Student is responsible for housing arrangements)
- ☐ **Contact Advisor**

Name: \_\_\_\_\_ Room: \_\_\_\_\_

Phone: \_\_\_\_\_ Email: \_\_\_\_\_

- ☐ **Enroll for classes** – see <http://www.reg.msu.edu/ROInfo/EnReg/CEInfomation.asp>



Michigan State University  
Credit Evaluation  
Graduate Program

Name \_\_\_\_\_ PID \_\_\_\_\_

Credit from \_\_\_\_\_ Date taken \_\_\_\_\_

Total Credits Transferred \_\_\_\_\_ Equivalent number of  
MSU semester credits \_\_\_\_\_

College \_\_\_\_\_ Major \_\_\_\_\_ Degree \_\_\_\_\_

Entered \_\_\_\_\_ Date \_\_\_\_\_

Explanation and Instructions

This form is to be used for the evaluation of graduate credit earned at another accredited institution.

1. Listed in column (1) are graduate level subjects previously completed at another accredited institution.
2. In column (2) are the semester or term credits previously earned in subjects listed in column (1).
3. Column (3) may be used for those departments and/or colleges which desire to make a specific subject listing for evaluation purposes. Three term credits equal two semester credits (e.g. Chemistry 800 - 6 term credits equal 4 semester credits).
4. In column (4) the department and/or college will indicate the number of semester credits to be accepted in transfer. (Subject by subject or by total only.) (400 level and 800 level courses should be identified here).
5. When the evaluation has been completed and approved by the Dean's Office, the original evaluation must be sent to the Admissions Office with an official transcript from the institution. Copies should be filed by the Dean's Office and the Departmental/Unit office.
6. A copy of a transfer course summary worksheet will be sent to the student upon completion.

(1) Transfer Subjects Dept. or Course Title Course No.	(2) TERM CRS. SEM. CRS	(3) Corresponding MSU Subjects Department Course No. Sem. Credits	(4) Accepted MSU Credits

\_\_\_\_\_  
Signature of Chairperson Date

\_\_\_\_\_  
Signature of Dean Date

MSU IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY INSTITUTION

MICHIGAN STATE UNIVERSITY  
COLLEGE OF ENGINEERING

TRANSFER FROM M.S. TO Ph.D. PROGRAM

Section 1 of the College of Engineering Ph.D. program regulations gives general criteria governing the transfer from M.S. to Ph.D. programs.

Request by Student:

\_\_\_\_\_ Name \_\_\_\_\_  
Date PID

Proposed Doctoral Area \_\_\_\_\_

I expect to complete the requirements for my M.S. degree in \_\_\_\_\_  
during \_\_\_\_\_ semester, and hereby request that I be considered for  
transfer to the indicated doctoral program.

\_\_\_\_\_  
Signature

Department Action:

It is (recommended not recommended) that the transfer to the indicated doctoral  
program be approved.

Provisional requirements: \_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
Academic Advisor Date \_\_\_\_\_

\_\_\_\_\_  
Department Chairperson Date \_\_\_\_\_

\_\_\_\_\_  
Associate Dean Date \_\_\_\_\_

Distribution: College (white)  
Department  
Student

TRANSFER.PHD

**Department of Electrical and Computer Engineering  
Michigan State University**

**Advisor Approval of Transfer from Master's Program to Doctoral Program**

Student Name \_\_\_\_\_

Student GPA /#credits \_\_\_\_\_

Current ECE 899 Grade:

Deferred \_\_\_\_\_  
Assigned as \_\_\_\_\_  
Not Applicable \_\_\_\_\_

Staff signature

I approve of the request by the above student to transfer from the Master's Program in Electrical Engineering to the Doctoral Program in Electrical Engineering and will serve as chair of the Ph.D. Guidance Committee. Contingent upon continued adequate funding and satisfactory performance, it is my intention to provide graduate assistantship support.

Academic Advisor \_\_\_\_\_

Date \_\_\_\_\_

If the GPA is below 3.5, please provide a rationale for admission approval in spite of the relatively low GPA. Additional pages may be used for this purpose.

## Appendix 8 - Courses

This appendix lists ECE courses that may be considered for inclusion in graduate programs. For more detailed information, such as the current course syllabus, please see the web site <http://www.egr.msu.edu/ece/students/courses/> . For course descriptions from other departments at Michigan State University, please see the web site <http://www.reg.msu.edu/Courses/search.asp> .

Note that 400 level courses are not used in counting the 36 credit post-bachelors minimum for doctoral programs. Also, please see section 3, Degree Requirements, regarding the minimum number of 800 or higher level credits required for master's programs. Graduate students who have not had the prerequisites for 400 level classes, i.e. mainly those students whose bachelor's degree is from another college or university will require course overrides to take 400 level classes. This is because the MSU registration system automatically checks for prerequisites for 400 or lower level courses. Course override forms may be obtained from the ECE main office, 2120 EB, or from the web site <http://www.egr.msu.edu/ece/courses/eceoverride.html> .

### **ECE 402 Applications of Analog Integrated Circuits**

**Semester:** Spring of every year.

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 3*  
4(3-3)

**Prerequisite:** (ECE 302 and ECE 303)

**Restrictions:** Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering.

**Description:** Circuit design using analog integrated circuits. SPICE macromodeling. Operational amplifiers, comparators, timers, regulators, multipliers and converters. Design project with hardware and software verification.

### **ECE 405 Electromagnetic Fields and Waves II**

**Semester:** Fall of every year.

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 3*  
4(3-3)

**Prerequisite:** (ECE 305)

**Restrictions:** Open only to juniors or seniors or graduate students in the Electrical Engineering major and to juniors or seniors in the Computer Engineering major.

**Description:** Microwave networks. Scattering parameters. Solutions to Coulomb's law, Gauss' Law and the wave equation. Planar transmission lines. Antennas. Waveguides and cavities. Measurement of the properties of antennas and microwave networks.

**ECE 407 Electromagnetic Compatibility**

**Semester:** Spring of every year.

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 3*  
4(3-3)

**Prerequisite:** (ECE 202 and ECE 305 and ECE 366)

**Restrictions:** Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer Engineering major.

**Description:** Electromagnetics for electrical systems. Signals and spectra. Regulations. Radiated and conducted emissions. Conducted and radiated immunity. Mitigation techniques.

**ECE 410 VLSI Design**

**Semester:** Fall of every year. Spring of every year.

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 3*  
4(3-3)

**Prerequisite:** (ECE 302 and ECE 303 and ECE 230)

**Restrictions:** Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering.

**Description:** Digital integrated circuit design fundamentals. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standards, silicon compilers, foundries. Design layout rules, rule checking. Circuit extraction, simulation, verification. Team-based design.

**ECE 411 Electronic Design Automation**

**Semester:** Fall of every year. Spring of every year.

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 3*  
4(3-3)

**Prerequisite:** (CSE 320 or ECE 331)

**Restrictions:** Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering.

**Description:** Electronic circuit design hierarchy and the role of methodology. Application specific integrated circuits. Hardware description languages. Behavioral and structural circuit modeling. Design algorithms and design tools. Design projects.

**ECE 415 Computer Aided Manufacturing**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 2 Lab Hours: 3* 3(2-3)

**Prerequisite:** (ECE 313 or ME 451)

**Restrictions:** Open only to juniors or seniors in the Manufacturing Engineering major.

**Description:** CAD/CAM fundamentals, programmable controllers, numerical control, NC part programming, sensors, data acquisition systems.

**ECE 416 Digital Control**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 2 Lab Hours: 3* 3(2-3)

**Prerequisite:** (ECE 303 and ECE 313)

**Restrictions:** Open only to juniors or seniors in the Electrical Engineering major or Computer Engineering major.

**Description:** State-space models. Analysis and design of control systems using state models. Digital control. Discrete-models of sampled-data systems. Quantization effects and sample-rate selection. System identification. Simulation of nonlinear control systems. Examples of nonlinear phenomena. State of the art of control engineering. Control laboratory.

**ECE 418 Algorithms of Circuit Design**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Prerequisite:** (ECE 302 and ECE 303 and ECE 366)

**Restrictions:** Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering.

**Description:** Design of analog electrical circuits, filter functions, ladder synthesis, inductor simulation. Vector Newton-Raphson method. Lossy inductance and capacitance. Statistical tolerance analysis. Optimization by multi-dimensional search. Software algorithms.

**ECE 420 Machines and Power Laboratory**

**Semester:** Spring of every year.

**Credits:** Total Credits: 1 *Lecture/Recitation/Discussion Hours: 3* 1(3-0)

**Prerequisite:** (ECE 320 or concurrently or ECE 423 or concurrently)

**Restrictions:** Open only to juniors or seniors in the Department of Electrical and Computer Engineering.

**Description:** Experimental investigation of machines, power electronics and power systems. Experimental verification of material found in introductory courses on energy conversion with extension to power electronics and power systems.

**ECE 423 Power System Analysis**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3 3(3-0)*

**Prerequisite:** (ECE 320)

**Restrictions:** Open only to juniors or seniors in the Department of Electrical and Computer Engineering.

**Description:** Synchronous machines. Models and measurements of power components. Symmetrical components. Short-circuit analysis and equipment protection. Load flow. Voltage and frequency control. Operation and planning of power systems.

**ECE 457 Communication Systems**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3 3(3-0)*

**Prerequisite:** (ECE 302 and ECE 366)

**Restrictions:** Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering.

**Description:** Representation and processing of signals in the presence of noise. System performance. Modulation, detection, and coding of information. System design applications in radar, sonar, radio, television, satellite communications, digital telephony, and wireless systems.

**ECE 458 Communication Systems Laboratory**

**Semester:** Spring of every year.

**Credits:** Total Credits: 1 *Lab Hours: 3 1(0-3)*

**Prerequisite:** (ECE 303 and ECE 457 or concurrently)

**Description:** A projects laboratory in communication systems.

**ECE 466 Digital Signal Processing and Filter Design**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3 3(3-0)*

**Prerequisite:** (ECE 366)

**Restrictions:** Open only to seniors or graduate students in the Department of Electrical and Computer Engineering.

**Description:** Discrete Fourier transforms, sampling theorem, circular convolution, Z-transforms. Design of infinite impulse resistance filters using prototypes and algorithmic methods. Design of finite impulse resistance filters by windowing, frequency sampling.

**ECE 474 Principles of Electronic Devices**

**Semester:** Fall of every year. Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Prerequisite:** (ECE 302 and ECE 305)

**Description:** Energy levels in atoms. Crystal properties, energy bands and charge carriers, semiconductors, transport properties of bulk materials. P-n junction diodes, bipolar transistors, field effect transistors.

**ECE 476 Electro-Optics**

**Semester:** Fall of every year. Summer of every year.

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 3* 4(3-3)

**Prerequisite:** (ECE 302 and ECE 303 and ECE 305)

**Restrictions:** Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer Engineering major.

**Description:** Operational theory, characteristics and applications of optical components, light emitting diodes, lasers, laser diodes, photodetectors, photovoltaics, fiber optics, optical modulators and non-linear optical devices

**ECE 477 Microelectronic Fabrication**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 2 Lab Hours: 3* 3(2-3)

**Prerequisite:** (ECE 474 or concurrently)

**Restrictions:** Open only to juniors or seniors in the Department of Electrical and Computer Engineering.

**Description:** Microelectronic processing fundamentals and simulations. Comparison of current microfabrication technologies and their limitations.

**ECE 480 Senior Design**

**Semester:** Fall of every year. Spring of every year.

**Credits:** Total Credits: 5 *Lecture/Recitation/Discussion Hours: 3 Lab Hours: 6* 5(3-6)

**Prerequisite:** (ECE 303 and ECE 313 and ECE 320 and ECE 331 and ECE 366) or (CSE 410 and CSE 420) and completion of Tier I writing requirement.

**Restrictions:** Open only to seniors in the Department of Electrical and Computer Engineering.

**Description:** Electrical engineering and computer engineering senior design experience involving contemporary design tools and practices, engineering standards, ethics, cross-functional teaming, oral and written technical communication, lifelong learning.



**ECE 490 Independent Study**

**Semester:** Fall of every year. Spring of every year. Summer of every year.

**Credits:** Variable from 1 to 3

**Reenrollment Information:** A student may earn a maximum of 3 credits in all enrollments for this course.

**Restrictions:** Approval of department.

**Description:** Independent study of a topic in electrical engineering or computer engineering.

**ECE 491 Special Topics**

**Semester:** Fall of every year. Spring of every year. Summer of every year.

**Credits:** Variable from 1 to 4

**Reenrollment Information:** A student may earn a maximum of 6 credits in all enrollments for this course.

**Restrictions:** Open only to students in the Department of Electrical and Computer Engineering.

**Description:** Investigation of special topics in electrical engineering or computer engineering.

**ECE 499 Undergraduate Research**

**Semester:** Fall of every year. Spring of every year. Summer of every year.

**Credits:** Variable from 1 to 3

**Reenrollment Information:** A student may earn a maximum of 4 credits in all enrollments for this course.

**Restrictions:** Approval of department.

**Description:** Independent undergraduate research in contemporary areas of electrical engineering or computer engineering.

**ECE 801 Independent Study**

**Semester:** Fall of every year. Spring of every year. Summer of every year.

**Credits:** Variable from 1 to 3

**Reenrollment Information:** A student may earn a maximum of 3 credits in all enrollments for this course.

**Restrictions:** Approval of department.

**Description:** Independent investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

**ECE 802 Selected Topics**

**Semester:** Fall of every year. Spring of every year.

**Credits:** Variable from 1 to 4

**Reenrollment Information:** A student may earn a maximum of 21 credits in all enrollments for this course.

**Description:** Investigation of special topics in electrical engineering.

**ECE 807 Computer System Performance and Measurement**

**Semester:** Spring of odd years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (CPS 410 and STT 441)

**Restrictions:** Open only to Computer Science or Electrical Engineering majors.

**Description:** Queueing network modelling, general analytic techniques, workload characterization, representing specific subsystems, parameterization. Software and hardware monitors, performance measures. Case studies, software packages.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Computer Science and Engineering

**ECE 808 Modelling and Discrete Simulation**

**Semester:** Fall of even years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (CPS 330 and STT 441)

**Restrictions:** Open only to Computer Science or Electrical Engineering majors.

**Description:** Simulation examples, and languages. Mathematical models, petri nets, model validation, random variate generation. Analysis of simulation data. Case studies.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Computer Science and Engineering

**ECE 809 Algorithms and Hardware Implementation**

**Semester:** not currently offered

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Arithmetic, signal processing, and image processing algorithms. Array structures: systolic architecture, data flow structure, neural network architecture. Performance analysis.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Electrical and Computer Engineering

**ECE 813 Advanced VLSI Design**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Prerequisite:** (ECE 410)

**Description:** Advanced topics in digital integrated circuit design. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standard cells. Design-rule checking. Circuit extraction, simulation, verification. Team-based design.

**Semester Alias:** EE 813

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Electrical and Computer Engineering

**ECE 814 Embedded Wireless RF Transceivers**

**Semester:** Fall of even years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Transceiver architecture designs. Software components. Real-time computing and synchronization on digital signal processing platforms, embedded software transceivers, receiver hardware and software considerations, signal structures and CDMA codes, real-time acquisitions and tracking, synchronization, software receivers.

**ECE 816 Cryptography and Network Security**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Major security techniques, including authenticity, confidentiality, message integrity, non-repudiation, and the mechanisms to achieve them. Network security and system security practices, including authentication practice, e-mail security, IP security, Web security, and firewalls.

**ECE 818 Robotics**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3*  
3(3-0)

**Recommended Background:** (ECE 313 or ME 451)

**Restrictions:** Open only to graduate students in the College of Engineering.

**Description:** Robot modeling, kinematics, dynamics, trajectory planning, programming, sensors, controller design.

**ECE 820 Advanced Computer Architecture**

**Semester:** Fall of every year. Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (CPS 410 and CPS 420)

**Restrictions:** Open only to Computer Science or Electrical Engineering majors.

**Description:** Instruction set architecture. Pipelining, vector processors, cache memory, high bandwidth memory design, virtual memory, input and output. Benchmarking techniques. New developments related to single CPU systems.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Computer Science and Engineering

**ECE 821 Advanced Power Electronics and Applications**

**Semester:** Fall of odd years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Power semiconductor devices, circuits, control, and applications. Converter and inverter analysis and design, DSP control and implementation. Automotive and utility applications.

### **ECE 822 Parallel Processing Computer Systems**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3*  
3(3-0)

**Recommended Background:** (CPS 820)

**Restrictions:** Open only to Computer Science or Electrical Engineering majors.

**Description:** Massively parallel SIMD processors, multiprocessor architectures, interconnection networks, synchronization and communication. Memory and address space management, process management and scheduling. Parallel compilers, languages, performance evaluation.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Computer Science and Engineering

### **ECE 823 Power System Stability and Control**

**Semester:** Fall of even years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 826)

**Description:** Analysis and simulation of small and large disturbance stability of power systems. Generator, exciter, voltage regulator models. Design of excitation systems and power system stabilizers.

### **ECE 824 Power System Operation and Control**

**Semester:** Fall of odd years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 421 and STT 351)

**Description:** Operation planning of power systems including loadflow, unit commitment, production cost methods. On line operation and control including automatic generation control, economic dispatch, security assessment, state estimation.

### **ECE 825 Alternating Current Electrical Machines and Drives**

**Semester:** Spring of even years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 320)

**Description:** Analysis, modeling and design of synchronous, induction, and switched reluctance machines. Design drives for motion control and power system applications.

**ECE 826 Linear Control Systems** (*Number being changed to ECE 851*)

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (MTH 314)

**Description:** Vector spaces, representation, system description, solution to the state equations, stability, controllability and observability. Adjoints of linear maps. Eigenstructure assignment. Partial and full order observers. Disturbance decoupling.

**ECE 831 Analog Circuit Theory**

**Semester:** Fall of even years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Positive real functions. Filter approximations. Passive and active network synthesis. Nullor network analysis and synthesis. Active filters. Stability. Sensitivity.

**ECE 832 Analog Integrated Circuit Design**

**Semester:** Fall of odd years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Technology. Device modeling. Circuit simulation. Integrated circuit building blocks. Amplifiers, comparators, converters. Switched-capacitor filters. Analog signal processing circuits.

**ECE 835 Advanced Electromagnetic Fields and Waves I**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Electrostatics, magnetostatics, electrodynamics and Maxwell's equations. Potential functions. Eigenfunction expansion. Green's functions. Radiation of EM waves. EM boundary-value problems. TEM waves. Maxwell's equations with magnetic sources.

**ECE 836 Advanced Electromagnetic Fields and Waves II**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 835)

**Description:** Theory of guided transmission system. Microstrip lines, metallic and dielectric waveguides. EM cavities. Excitation and discontinuities of waveguides. Surface wave and radiation modes. Integrated optics. Scattering of EM waves.

**Course: ECE 841 Fourier Optics****Semester:** (not currently offered)**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 2    Lab Hours: 3    3(2-3)***Recommended Background:** (ECE 360) and (ECE 435 or ECE 835)**Description:** Scalar diffraction theory. Fourier expansion of optical fields. Spatial linear systems and information processing. Lenses. Optical imaging systems. Holography. Measurements of optical systems.**ECE 842 Quantum Electronics****Semester:** not currently offered.**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3    3(3-0)***Recommended Background:** (ECE 835 and ECE 874)**Description:** Quantum and electromagnetic theory of lasers. Optical resonators. Laser oscillation and amplification. Characterization of lasers. Specific laser examples.**ECE 850 Electrodynamics of Plasmas****Semester:** Spring of odd years.**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3    3(3-0)***Recommended Background:** (ECE 835 or PHY 488)**Description:** Plasma kinetic and macroscopic plasma transport theory. Electromagnetic wave propagation and charged particle diffusion processes in plasma. Electromagnetic energy absorption via elastic and inelastic collisions. Dc, rf, and microwave discharges.**Interdepartmental With:** Astronomy and Astrophysics , Physics**Administered By:** Electrical and Computer Engineering**ECE 853 Optimal Control****Semester:** Spring of odd years**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3    3(3-0)***Description:** Static optimization. Nonlinear optimal control of discrete and continuous systems, with specialization to the LQ regulator and tracking. Extending the deterministic results to the Kalman filter and the LQG regulator. Dynamic programming and inequality constraints. Convex optimization and LMI's.**Interdepartmental With:** Mechanical Engineering

**ECE 854 Robust Control**

**Semester:** Spring of even years

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Restrictions:** Open to students in the College of Engineering and approval of college.

**Description:** Linear systems and norms for signals and systems. Investigation of stability and performance of control systems. Model reduction, uncertainty, and robustness. Parameterization of stabilizing controllers, Ricatti equations and related factorizations. Application to H-2, H-infinity, and L-1 control.

**Interdepartmental With:** Mechanical Engineering

**Administered By:** Mechanical Engineering Effective

**ECE 859 Nonlinear Systems and Control**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 826 and ME 857)

**Description:** Second-order systems. Fundamental properties of solutions. Lyapunov stability. Input-output stability. Passivity. Absolute stability. Linearization. Integral control. Feedback linearization. Sliding mode control. Lyapunov redesign. Passivity-based control. Recursive methods. Applications to electrical and mechanical systems.

**Interdepartmental With:** Mechanical Engineering

**Administered By:** Electrical and Computer Engineering

**ECE 863 Analysis of Stochastic Systems**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (STT 441)

**Description:** Advanced topics in random variable theory. Stochastic processes and stochastic calculus. Optimal systems for filtering and detection.

**ECE 864 Detection and Estimation Theory**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 863)

**Description:** Analysis and implementation of statistical estimation and detection methods used in signal processing, communications, and control applications. Bayesian, Neyman-Pearson, and minimax detection schemes. Bayesian, mean-square-error, and maximum-likelihood estimation methods.

**ECE 865 Analog and Digital Communications**

**Semester:** Fall of odd years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 457 and ECE 863)

**Description:** Optimum signal design in noisy channels, matched filters, quadrature sampling of band-pass signals in noise. Coherent and non-coherent binary modulation such as PSK, FSK, DPSK, M-ary modulation, intersymbol interference, spread spectrum.

**ECE 867 Information Theory and Coding**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Prerequisite:** (ECE 863)

**Description:** Shannon information measures. Uniqueness theorem and chain rules of the entropy measures. Kullback-Leibler relative-entropy. The I-measure. Asymptotic Equipartition Property (AEP) for various sources. Channel capacity; discrete-memoryless and symmetric channels. The channel coding theorem. Rate-distortion theory. Applications of coding to modern communications and compression methods such as image, video, speech and watermarking.

**ECE 870 Introduction to Micro-Electro-Mechanical Systems**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 477 and ECE 474)

**Description:** Micro-electro-mechanical systems (MEMS). Fundamentals of micromachining and microfabrication techniques. Design and analysis of devices and systems in mechanical, electrical, fluidic, and thermal energy and signal domains. Sensing and transduction mechanisms, including capacitive and piezoresistive techniques. Design and analysis of miniature sensors and actuators. Examples of existing devices and their applications.

**ECE 871 Micro-electro-mechanical Systems Fabrication**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Prerequisite:** (ECE 870 or ECE 477)

**Description:** Development of a complete integrated microsystem from inception to final test. Design, fabrication and testing of integrated microsystems. Development of a complete multichip microsystem containing sensors, signal processing, and an output interface. Basic MOS device and circuit processes, wafer bonding and micromachining, low power portable devices and diamond MEMS chips.



**ECE 874 Physical Electronics**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Applications of quantum mechanics and statistical mechanics in solids. Band theory of semiconductors. Electrical transport phenomena. Pn junctions.

**ECE 875 Electronic Devices**

**Semester:** Spring of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 874)

**Description:** Operating properties of semiconductor devices including DC, AC, transient and noise models of FET, BJT, metal-semiconductor contact, heterostructure, microwave and photonic devices.

**ECE 885 Artificial Neural Networks**

**Semester:** Fall of every year.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Description:** Overview of neuro-engineering technology. Basic neural network architectures. Feedforward and feedback networks. Temporal modeling. Supervised and unsupervised learning. Implementation. Basic applications to pattern recognition.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Electrical and Computer Engineering

**ECE 899 Master's Thesis Research**

**Semester:** Fall of every year. Spring of every year. Summer of every year.

**Credits:** Variable from 1 to 8

**Reenrollment Information:** A student may earn a maximum of 24 credits in all enrollments for this course.

**Description:** Master's thesis research.

**ECE 920 Selected Topics in High Performance Computer Systems**

**Semester:** Please consult with ECE Faculty in the area of Computer Engineering.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Reenrollment Information:** A student may earn a maximum of 9 credits in all enrollments for this course.

**Recommended Background:** (CPS 822)

**Restrictions:** Open only to Computer Science or Electrical Engineering majors.

**Description:** Design of high performance computer systems. Seminar format.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Computer Science and Engineering

### **ECE 921 Advanced Topics in Digital Circuits and Systems**

**Semester:** Please consult with ECE Faculty in the area of Computer Engineering. This course is offered either as ECE 921A or ECE 921B (see descriptions below).

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Reenrollment Information:** A student may earn a maximum of 6 credits in all enrollments for this course.

**Description:** Topics vary each semester.

**Interdepartmental With:** Computer Science and Engineering

**Administered By:** Electrical and Computer Engineering

### **ECE 921A Testable and Fault-tolerant Digital Systems**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 809 and ECE 813)

**Description:** Reliability evaluation. Fault models and test pattern generation. Design for testability. Fault-tolerant design techniques, self-checking circuits and systems, system diagnosis and reconfiguration.

### **ECE 921B Embedded Architectures**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 809 and ECE 813)

**Description:** Embedded computers and architectures for real-time computation and/or robust control. ASICs. Bit-slice architectures. Systolic arrays. Neural networks. Genetic algorithms. Implementation technologies and design issues.

### **ECE 925 Advanced Topics in Power**

**Semester:** Please consult with ECE Faculty in the area of Power. This course is offered as ECE 925C (see description below).

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Reenrollment Information:** A student may earn a maximum of 9 credits in all enrollments for this course.

**Description:** Topics vary each semester.

### **ECE 925C Advanced Machine Drives**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 825 and ECE 829)

**Description:** Nonlinear drives based on state reconstruction and nonlinear and adaptive control. Sensors, implementation, special computer architectures.

**Course: ECE 929 Advanced Topics in Electromagnetics**

**Semester:** Please consult with ECE Faculty in the area of Electromagnetics. This course is offered as ECE 929A, ECE 929B, and ECE 921C (see descriptions below).

**Credits:** Variable from 3 to 4

**Reenrollment Information:** A student may earn a maximum of 10 credits in all enrollments for this course.

**Description:** Topics vary each semester.

**ECE 929A Planar Waveguides and Circuits**

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 835)

**Description:** Planar open-boundary waveguides and circuits. Surface and microstrip waveguides. Propagation-mode spectrum. Spectral analysis of layered media. Sommerfeld analysis. Integral-operator description of open waveguides and planar circuits.

**ECE 929B Antenna Theory**

**Credits:** Total Credits: 4 *Lecture/Recitation/Discussion Hours: 4* 4(4-0)

**Recommended Background:** (ECE 835)

**Description:** Antennas and EM scattering. Radiation by currents and surface fields. Equivalence principle. Receiving antennas. Arrays and synthesis. Integral equations. Current and impedance of wire antennas. Slot, aperture and reflector antennas. Singularity expansion method.

**ECE 929C Geometrical Theory of Diffraction**

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 835)

**Description:** Fourier expansion and asymptotic evaluation of two-dimensional electromagnetic fields. Scattering from half-planes, wedges and cylinders. Geometrical optics and ray-tracing. Reflection and transmission matrices. Geometrical diffraction theory.

**ECE 931 Advanced Topics in Electronic Devices and Materials**

**Semester:** Please consult with ECE Faculty in the area of Electronic Materials and Devices. This course is offered as ECE 931A, ECE 931B, and ECE 931C (see descriptions below).

**Credits:** Variable from 1 to 4

**Reenrollment Information:** A student may earn a maximum of 12 credits in all enrollments for this course.

**Description:** Topics vary each semester.

**ECE 931A VLSI Technology**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 875)

**Description:** Oxidation, doping techniques, simulation techniques, film deposition and etching, epitaxial growth, lithography, passivation, and packaging.

**ECE 931B Microdevices and Microstructures**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 875)

**Description:** Technology, modeling and simulation of submicron solid state devices. Microsensors and micromachining. Diamond and superconducting devices. Vacuum microelectronic structures.

**ECE 931C Properties of Semiconductors**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 874)

**Description:** Carrier scattering, single particle and collective transport, quantum effects, hot electron effects, electron-photon and electron-phonon interactions.

**ECE 932 Advanced Topics in Analog Circuits**

**Semester:** Please consult with ECE Faculty in the area of Computer Engineering.

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Description:** Variable topics in advanced circuit analysis.

**ECE 960 Advanced Topics in Control**

**Semester:** Please consult with ECE Faculty in the area of Controls. This course is offered as either ECE 960A or ECE 960B (see descriptions below).

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Reenrollment Information:** A student may earn a maximum of 6 credits in all enrollments for this course.

**Recommended Background:** (ECE 827 and ECE 829)

**Description:** Topics vary each semester.

**ECE 960A Adaptive Control**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 827 and ECE 829)

**Description:** Model reference adaptive control in continuous and discrete time. Lyapunov and hyperstability approaches, adaptive observers, self-tuning regulators, design using pole-zero assignments. Minimum variance and LQG control.

**ECE 960B Nonlinear Control**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 827 and ECE 829)

**Description:** Relay control, stabilizing controllers. Design via variable structure, high gain, geometric, and Lyapunov-based methods. Feedback linearization and tracking controls.

**ECE 963 Advanced Topics in Systems**

**Semester:** Please consult with ECE Faculty in the area of Systems.

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Reenrollment Information:** A student may earn a maximum of 9 credits in all enrollments for this course.

**Description:** Topics vary each semester.

**ECE 966 Advanced Topics in Signal Processing**

**Semester:** Please consult with ECE Faculty in the area of Signal Processing. This course is offered as ECE 966A, ECE 966B, and ECE 966C (see descriptions below).

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Reenrollment Information:** A student may earn a maximum of 9 credits in all enrollments for this course.

**Description:** Topics vary each semester.

**ECE 966A Discrete Time Processing of Speech Signals**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 466 and ECE 863 and ECE 864)

**Description:** Digital speech models. Short term temporal processing. Linear predictive and spectral analysis. Speech coding and synthesis, recognition, enhancement.

**ECE 966B Multidimensional Signal Processing**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 466 and ECE 864)

**Description:** Multidimensional signals and systems concepts. Two-dimensional sampling, windowing, filter design. Fast algorithms for convolution and transforms. Sensor array processing. Interpolation.

**ECE 966C Advanced Topics in Statistical Signal Processing**

**Credits:** Total Credits: 3    *Lecture/Recitation/Discussion Hours: 3*    3(3-0)

**Recommended Background:** (ECE 466 and ECE 863 and ECE 864)

**Description:** Communication channels, noise models, hypothesis testing of signals by Bayesian minimax, and Neyman-Pearson criteria. Performance evaluation using ROC. Bayesian and maximum likelihood parameter estimation. Kalman-Bucy filtering.

**ECE 989 Advanced Topics in Plasma**

**Semester:** Please consult with ECE Faculty in the area of Plasmas. This course is offered as ECE 989A (see description below).

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Reenrollment Information:** A student may earn a maximum of 6 credits in all enrollments for this course.

**Description:** Topics vary each semester.

**ECE 989A Plasma Processing for IC Fabrication**

**Semester:** Fall of odd years. Spring of odd years.

**Credits:** Total Credits: 3 *Lecture/Recitation/Discussion Hours: 3* 3(3-0)

**Recommended Background:** (ECE 835 and ECE 850)

**Description:** Process requirements. Plasma reactors. Etching and deposition applications. Broad ion beam processing.

**ECE 999 Doctoral Dissertation Research**

**Semester:** Fall of every year. Spring of every year. Summer of every year.

**Credits:** Variable from 1 to 24

**Reenrollment Information:** A student may earn a maximum of 72 credits in all enrollments for this course.

**Description:** Doctoral dissertation research.

## Appendix 9. Ph.D. Defense Template Announcement

### PhD Defense Presentation

Friday, March 2, 2012

2:00pm – 4:00pm

2219 Engineering Building

ECE Conference Room

“Title of the Dissertation”

By

Student’s Name

Advisor: Advisor’s Name

#### Abstract

Describe the objectives of the doctoral research and the scientific outcomes.

#### Journal Publications:

1. **Author 1**, Coauthor 1, and Coauthor 2, “Title of the publication”, *Name of the Journal*, vol. XX, no. XX, (Mon. Year), pp. XXX-XXX.

#### Journals under Review:

1. **Author 1**, Coauthor 1, and Coauthor 2, “Title of the publication”, *Name of the Journal*, vol. XX, no. XX, (Mon. Year), pp. XXX-XXX.

#### Books/Book Chapters:

1. **Author 1**, Coauthor 1, and Coauthor 2, “Title of the chapter”, *Name of the book*, (ed. Editor’s names), Publisher Name, Year of the Publication, ISBN.
2. **Author 1**, Coauthor 1, and Coauthor 2, *Name of the book*, Publisher Name, Year of the Publication, ISBN.

**Patents:**

1. **Inventor 1**, Inventor 2, and Inventor 3, “Title of the invention”, US patent no: XXXX, Issued on: Mon, DD, YYYY.

**Conference Proceedings:**

1. **Author 1**, Coauthor 1, and Coauthor 2, “Title of the publication”, *Name of the Conference Proceedings*, vol. XX, no. XX, (Mon. Year), pp. XXX-XXX.

**Conference Presentations and Meeting Abstracts:**

1. **Author 1**, Coauthor 1, and Coauthor 2, “Title of the publication”, *Name of the Meeting*, Location of the meeting, (Month Year).